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TWELFTH ANNUAL REVIEW OF ACTIVITIES

Project Résumés

1987

Edited by

Shasta A. Abbott

Minerals and Energy Division
Department of Natural Resources
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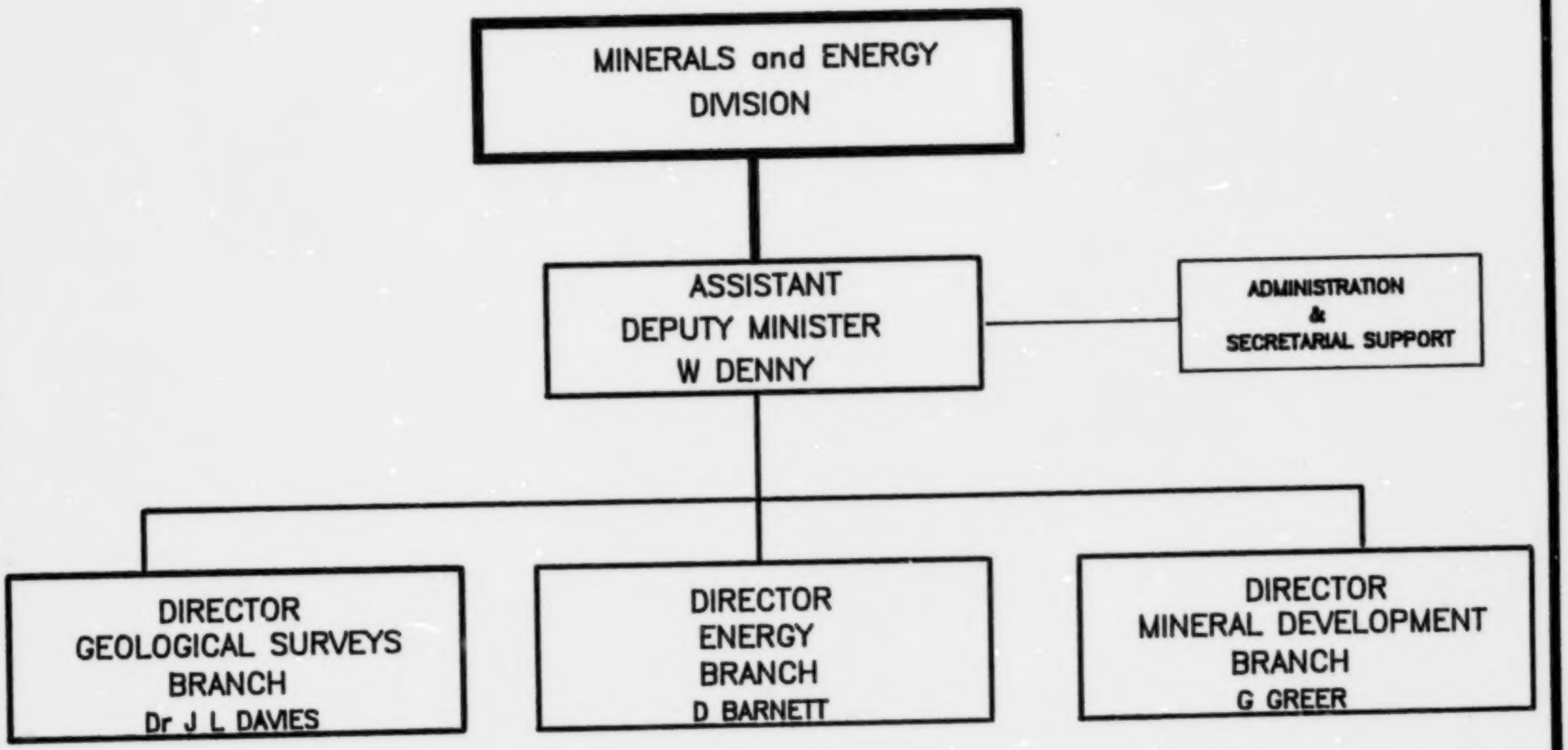


GEOLOGICAL SURVEYS BRANCH

BATHURST REGIONAL OFFICE

ACTIVITIES OF THE BATHURST REGIONAL OFFICE

J.L. Davies, Regional Geologist

The staff of the Bathurst Regional Office consists of Steven McCutcheon (Regional Geologist), J.A. MacIntosh (Assistant Regional Geologist), Sharon McKinnon (Administrative Services Officer), and André LeBlanc and Maurice Belland (Engineering Technicians). D.M. Burton and G.R. Philpott are contract geologists responsible for projects funded through the Canada-New Brunswick Mineral Development Agreement (MDA). T.G. Mersereau assisted in the MDA-funded geocompilation project. Most of the field work and data collection conducted from the Bathurst Regional Office utilizes MDA funds. Provincial budgets alone are not sufficient to sustain large projects.

CANADA-NEW BRUNSWICK MDA PROJECTS

D.M. Burton embarked on a geological-geochemical study of the new gold discoveries in the Upsalquitch Forks (21 O/10) map area. The aim of the project is to obtain a better understanding of the gold occurrences and their geological environments (page 7).

G.R. Philpott began an investigation of the Silurian and Devonian rocks in the Charlo River area. The area was chosen because of its potential for Carlin-type gold occurrences (page 13).

T.G. Mersereau supervised the production of twenty-five - 1:10 000 geoscience compilation maps for NTS map area 21 O/8. The maps were produced by Ken Whaley & Associates and Three-D Geoconsultants.

UNB completed the first year (Phase I) of their study of the Heath Steele Mine and are working on Phase II under the guidance of P.F. Williams, A.L. McAllister, and J.G. Torrance (page 17).

Approximately 1000 stream silt samples from 21 O/10, 21 O/2, and 21 O/9 collected in 1986 were analysed for gold, barium, arsenic, and antimony. Results were released in 1987.

Résumés on pages 4-18 inclusive provide more detailed information on the MDA projects carried out from the Bathurst Office during the 1987 field season.

PROVINCIAL PROJECTS

Geological Mapping:

J.A. MacIntosh completed his provincially-funded mapping project in the Heath Steele Mine area. The map and report covering this work is in preparation. In 1987, Mr. MacIntosh carried out geological mapping in the 21 O/9 area to resolve correlation problems arising with previous 1"=1/4 mile mapping.

Mineral Deposits:

R.R. Irrinki of the Fredericton office completed his work on the Key Anacon sulphide deposit in which computer-derived plans and sections were used for the first time (page 19). The Half Mile Lake sulphide deposit is the next deposit to be studied.

Diamond-drill Core:

In 1987, several thousand feet of diamond-drill core was collected from the Key Anacon and Mount Costigan sulphide deposits. Core-storage racks are being built at the Madran facility to accommodate the thousands of feet of core now piled at the site.

Other Activities:

Sharon McKinnon and André LeBlanc continued their work related to claim staking and recording. Claim data are now made available to the Regional Offices on disk, thus eliminating the Kardex system used for many years.

Mr. LeBlanc continued his duties related to updating claim maps and resolving plotting difficulties. He also drafted most maps generated by the geological staff.

M. Belland compiled exploration data in various parts of northern New Brunswick, and assisted the Regional Geologist in coordinating mineral exploration and forestry operation.

GEOLOGY, GEOCHEMISTRY, AND ECONOMIC POTENTIAL OF LOWER DEVONIAN VOLCANIC ROCKS ALONG THE JACQUET RIVER FAULT, NORTHERN NEW BRUNSWICK

D.M. Burton and G.R. Philpott, MDA Project Geologists

Volcanic and sedimentary rocks of the Lower Devonian Dalhousie Group underlie a narrow (1-7 km), east-northeast trending belt that extends 65 km from the Southeast Upsalquitch River to the village of Lorne in northern New Brunswick. The northern part of the belt comprises roughly equal proportions of mafic and felsic volcanic rocks whereas the southern part is dominated by mafic volcanic and sedimentary rocks (Figure 1). The Jacquet River Fault apparently terminates at the Rocky Brook-Millstream Fault in the south.

The northern part of this belt is characterized by geochemically anomalous stream sediments that are enriched in base metals and some gold pathfinder elements (Ag, As, Sb, and Ba) (Boyle *et al*. 1966). These anomalies are commonly associated with rhyolite flows and tuffs.

An extensive sampling program was undertaken, along the tributaries that transect the anomalous area, to ascertain whether or not the silt geochemistry was reflecting a direct bedrock source for the metals. Sampling was less intense to the south, where the felsic volcanic component pinches out. A number of drill holes were sampled for geochemical analyses and a suite of representative samples was collected for whole-rock lithogeochemical purposes. Over 500 samples were analysed for 25 elements and these data, together with five - 1:20 000 scale geological compilation maps showing the sample locations, will be published as Open File 87-18.

During the summer of 1986, a gold showing north of the Rocky Brook-Millstream Fault was discovered by Lacana Mining Corporation within mafic volcanic flows of the Dalhousie Group, proximal to the Jacquet River Fault near Nine Mile Brook (NTS 21 O/10). Mineralization consists of polymetallic (Cu-Pb-Au-Ag) quartz-calcite veins cutting a diorite intrusion. Trace-element studies indicate that anomalous Hg-Bi-(Sb) are associated with this mineralization.

A second Au-Ag discovery north of the Rocky Brook-Millstream Fault was made by Lacana at Rocky Brook in Silurian red beds. Samples taken by Departmental personnel prior to this discovery indicated anomalous Ag-As-Sb in altered red beds along Rocky Brook and Upper McNair Brook. Similar alteration was noted along an 800-m stretch of Four Mile Brook.

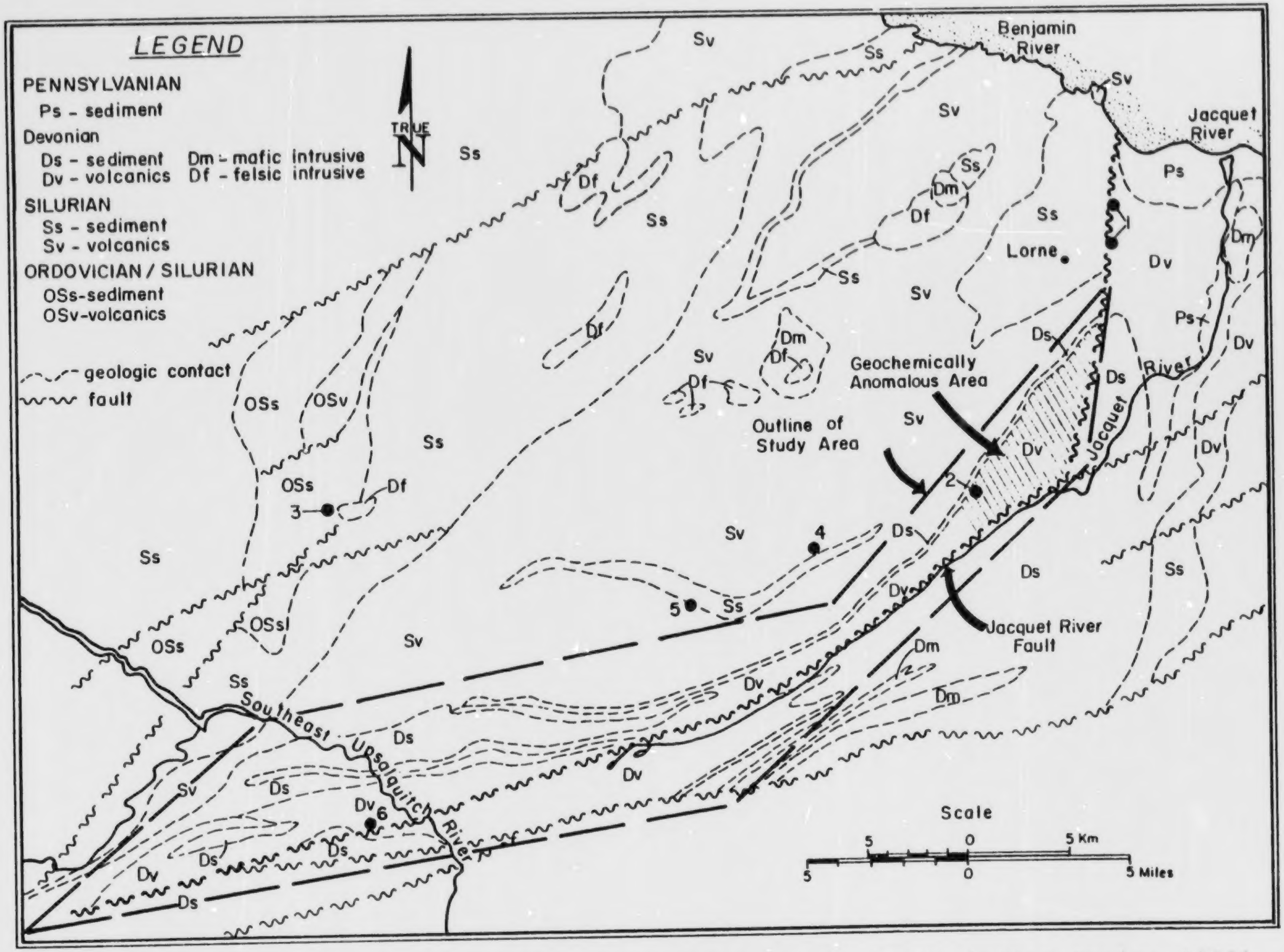


FIGURE 1. Generalized geology along the Jacquet River Fault (after Davies 1979). Mineral occurrences: 1. Nash Creek, 2. McNeill Brook, 3. Popelogan, 4. Upper McNair Bk., 5. Rocky Bk., 6. Nine Mile Bk.

The two discoveries north of the Rocky Brook-Millstream Fault clearly demonstrate that potential exists within the Siluro-Devonian succession for precious-metal "epithermal" and stockwork-type deposits. Chalcedonic veining and subsequent open space crystal growth at the Rocky Brook showing appears to have followed a pervasive greenish alteration of the surrounding sedimentary and volcaniclastic rocks. This alteration is readily recognized in the field making it an effective exploration tool. Further geochemical and petrographic studies are required. The quartz-calcite stockwork system at Nine Mile Brook is unusual in its elemental associations, but has gross similarities to the altered auriferous intrusions south of the Rocky Brook-Millstream Fault.

The source of metals (including manganese) in the silts from the northern tributaries has yet to be determined. However, the results of this study, coupled with the recent gold discoveries, provide a new focus for exploration. A number of samples are clearly anomalous in Ag-As-Sb-Hg. There is a strong correlation between mercury in bedrock and anomalous metals in stream sediments in McLean Brook, Falls Gulch, and Hayes Gulch.

Recent airborne surveys have been conducted by the GSC over much of northern New Brunswick. The aeromagnetic vertical gradient map for the Charlo map sheet (21 O/16) shows a number of positive features coincident with areas anomalous in Hg-Sb in the McNeill Brook-Falls Gulch area. Airborne gamma ray spectrometric maps also pinpoint these areas, especially in the eTh, eU, TC(Ur), and K presentations. The significance of these airborne anomalies is poorly understood and certainly deserving of more attention by the exploration community.

Sulphide mineralization, discovered several years ago at McNeill Brook, occurs in a pillow basalt flow near the base of the Devonian section. This flow, which can be traced for 3 km from McNeill Brook to Lower McNair Brook, is characterized by a bismuth-molybdenum trace-element signature. The flow is considered to represent a favourable target for stratabound massive sulphides.

GEOLOGY AND MINERAL OCCURRENCES OF THE UPSALQUITCH FORKS MAP AREA (NTS 21 O/10)

D.M. Burton, J. Creamer, and B. Murphy - MDA

The Upsalquitch Forks map area (NTS 21 O/10), centred about 80 km west of Bathurst, has become the most active area for gold exploration in New Brunswick (Figure 2). Since 1984, over 10 gold occurrences and several bedrock gold anomalies have been found in the eastern half of the map area. In 1983 virtually no claims existed in the area, whereas at present there are over 1200 claims in the Upsalquitch Forks map area, and 800 claims on similar geologically favourable ground to the east in the Tetagouche Lakes map area (NTS 21 O/9).

In the spring of 1987, the New Brunswick Department of Natural Resources and Energy (NBDNRE) made available new 1:10 000 scale digitized base maps, culturally updated from 1985 aerial photographs for the entire 21 O/10 map area. In view of the recent exploration activity in the area, a mapping program was begun at a scale of 1:10 000 with a view to updating the existing 1/4 mile map series. This program was aided by many new outcrops on an extensive network of logging roads constructed over the past 12 years. At the same time, a more detailed examination of the gold occurrences was initiated to provide a better understanding of their geological setting and associated alteration. Regional mapping by John Creamer and Brent Murphy focused on the Tobique-Chaleur Subzone as this is the most important area in terms of current exploration activity. Sixteen of the twenty-five 1:10 000 sheets covering NTS map sheet 21 O/10, have been completed (Figure 3), leaving much of the Aroostook-Matapedia Subzone and all of the Miramichi Zone to be mapped. The Miramichi Zone portion will be mapped as part of Dr. van Staal's GSC contribution to the MDA (unavailable at time of printing), and the remaining parts will be mapped during the 1988 field season. A study of the mafic intrusive rocks is the subject of a master's thesis by Brent Murphy, to be carried out under the supervision of Dr. Sandra Barr of Acadia University and supported by the Department.

GEOLOGY

The Upsalquitch Forks map area is underlain by a diverse assemblage of Cambro-Ordovician to Upper Devonian rocks. Poly-deformed volcanic and sedimentary rocks of the Cambro-Ordovician Tetagouche Group (Miramichi Zone) crop out over a small part of the southeast corner of the area and represent less than 3% of bedrock. Sixty per cent of the area is underlain by Siluro-Devonian (Chaleurs and Dalhousie groups) sedimentary and volcanic rocks of the Tobique-Chaleur Subzone, which are host to all the recently discovered gold occurrences. Upper Ordovician to Lower Silurian (Matapedia and Grog Brook groups) sedimentary rocks of the Aroostook-Matapedia Subzone underlie

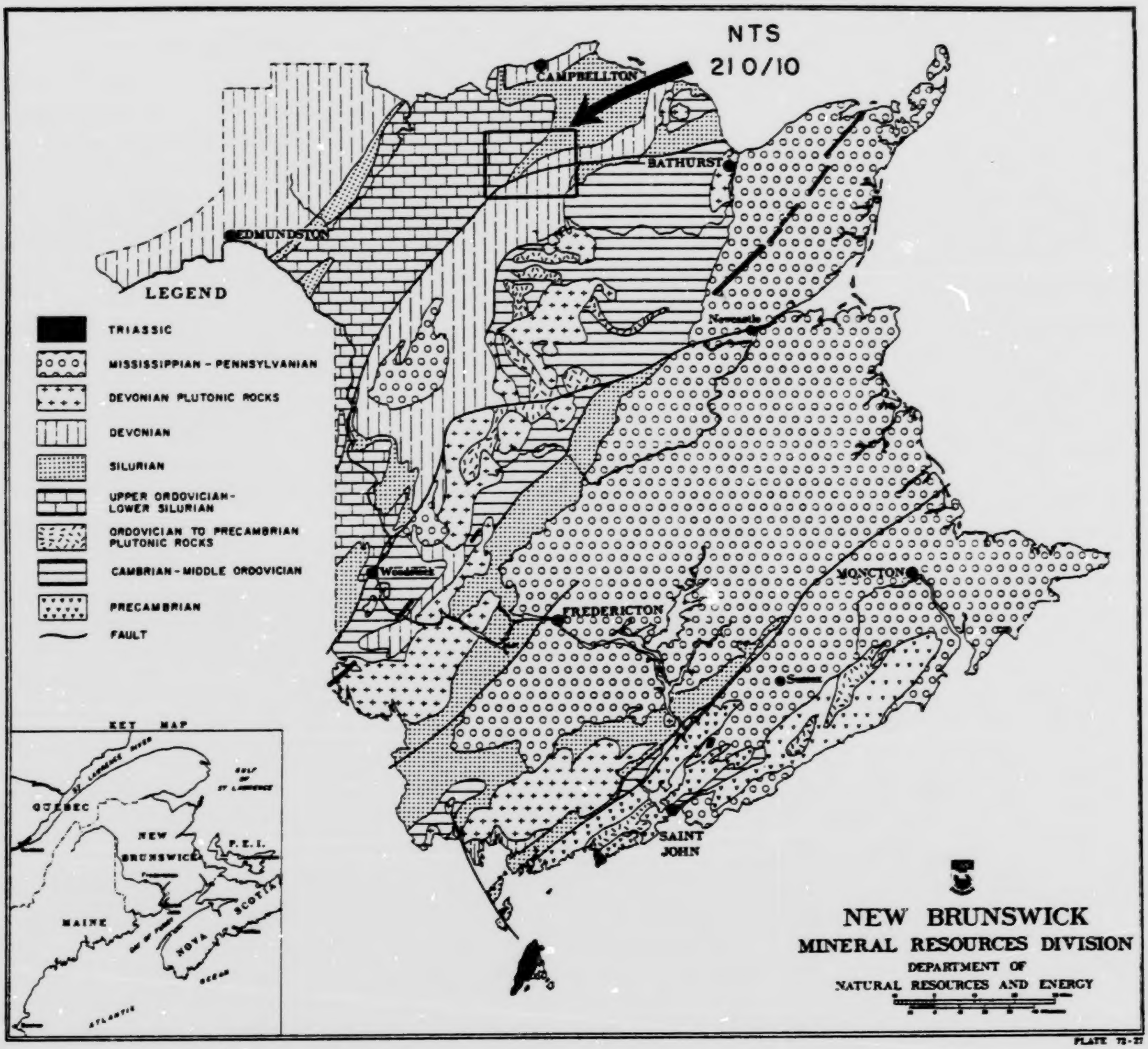
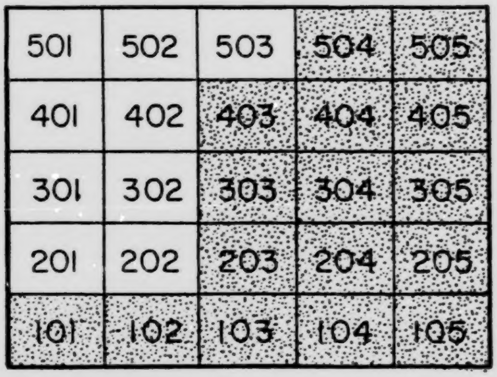


FIGURE 2. Geological map of New Brunswick showing location of Upsalquitch Forks map area (NTS 21 O/10).



501	502	503	504	505
401	402	403	404	405
301	302	303	304	305
201	202	203	204	205
101	102	103	104	105

FIGURE 3. 1:10 000 scale index showing map coverage of NTS 21 O/10 during 1987.

the northwestern part of the area. The entire map area is transected by a number of major east-northeast-trending faults, the most prominent being the Rocky Brook-Millstream Fault. Within the Tobique-Chaleur Subzone, a number of intrusions of mafic to intermediate composition are associated with these structural lineaments.

MINERALIZATION

Three styles of gold mineralization have been recognized in the Upsalquitch Forks area based on host-rock lithology; most likely they are all associated with the same mineralizing event. They are classified as follows:

1) auriferous mafic intrusions and associated auriferous siltstones/mudstones
2) auriferous intermediate intrusions
3) polymetallic auriferous quartz-calcite veins in mafic intrusions

The first type is characterized by intense carbonatization and silicification which is reflected by quartz-siderite veining in both intrusive and sedimentary rocks. Diamond drilling indicates alteration zones in excess of 200 m in thickness. Associated sulphide mineralization (pyrite ± arsenopyrite) is persistent, but typically less than 5%. Assays of up to 15 000 ppb Au have been obtained in grab samples. Sulphide concentrations of up to 50% occur locally. Carbonatization is widespread in the surrounding siltstones and shales, and these rusty weathering alteration zones are easily recognized in the field. Locally, flecks of an unidentified bright green mineral (Cr-mica?) are found in the altered rocks.

A distinctive sedimentary breccia is found in contact with many of the mafic intrusions. This rock type, which was first described in drill logs from the Simpsons Field occurrence by Noranda Exploration in 1985, was originally termed "olistostrome" and was taken to imply a melange of sedimentary origin. However, the term is now more specifically applied to submarine gravity flows so its usage in the case of the Upsalquitch breccias should be discontinued.

An examination of these breccias is being undertaken in conjunction with the gold-occurrence studies. The breccias are most commonly oligomictic, with finely laminated, angular siltstone clasts. Polymictic varieties carry 90% siltstone clasts with 10% subrounded mafic and felsic volcanic clasts; such breccias are not associated with the contacts of auriferous intrusions. Initially, all exposures of breccia were found to be in contact with mafic intrusions and no source for the distinctive siltstone clasts was known. Recent trenching activities have provided more exposures of breccia, and at a few localities it can be seen in contact with undisturbed siltstone. Outcrops of unbrecciated siltstone (protolith) have been mapped but such occurrences are rare.

Disseminated pyrite and rare, finely laminated pyrite occur in the protolith, suggesting that the pyrite mineralization in the altered breccias may predate the main alteration event. Fragments have undergone some hard-rock deformation prior to brecciation. Where the McCormack Brook Fault has been exposed in trenches, the breccias have been reduced to gouge. These observations suggest the following sequence of events:

1) deposition of the thinly laminated siltstone within a restricted environment
2) regional deformation affecting the siltstone unit
3) selective disruption of the siltstone unit giving rise to the breccias, either prior to or coeval with
4) intrusion of the mafic dykes and sills along major fault zones
5) widespread carbonatization, silicification, and locally, mineralization that is syn- to post-intrusion.

The breccias associated with the mineralization represent either diatremes (explosion breccias) or fault breccias. Poor outcrop exposures will necessitate reliance on drill core and petrographic studies to determine their origin. At this point in time, they represent one of the few successful guides to exploration in the area.

Auriferous intrusions of intermediate composition are less widespread. Gold values to date are in the 200-1000 ppb range, but, like their mafic counterparts, the associated alteration is pervasive and of undetermined extent. Altered feldspar porphyry, and minor quartz-feldspar porphyry, that was initially exposed in a single trench in 1985, has been mapped over an area of roughly 2 km^2. Brecciated siltstones and their protolith may also be represented along the intrusive contacts.

The recent discovery of polymetallic quartz-calcite veins carrying up to 10 350 ppb Au and 350 ppm Ag, is the first occurrence of its type in the map area. The veins are up to 1 m in thickness and cut an altered diorite intrusion that is in fault contact with porphyritic basalt flows.

IMPLICATIONS

The Upsalquitch Forks map area holds strong potential for an economic precious-metal discovery. Two geologic models may be applicable to, and explain the origin of the gold mineralization, i.e., volcanoplutonic and fault-controlled. If it has a volcanoplutonic origin, then the level of erosion may be favourable for deeper mineralization. The Upsalquitch breccias are similar to those described from diatremes in the Wernecke Mountains of the Yukon Territory (Bell 1986; Laznicka and Edwards 1979) and, by analogy, to breccias found in association with the giant Olympic Dam deposit in Australia.

Diatremes are commonly hosts to, or are associated with, gold deposits (Sillitoe 1985) in the western United States (i.e., Cripple Creek, Colorado and Montana Tunnels, Montana) and elsewhere (i.e., Porgera, Papua New Guinea).

If the mineralization is simply associated with selective alteration of intrusive bodies along faults, the potential is still high for a large tonnage, disseminated-type deposit as described by Boyle (1979). Economic deposits such as the Camflo and Lamaque mines of the Val-d'Or-Malarctic district in Quebec provide enticing models.

Despite the steady increase in exploration activity, large areas of favourable ground remain open for staking, especially west of the known gold occurrences. Systematic till sampling by Pronk (1986, 1987) of the Geological Surveys Branch, clearly shows that the strongest gold anomalies (up to 678 ppb in the C horizon) occur along major faults west and up-ice of the known occurrences. The tills are predominantly derived from local sources. Preliminary mapping in these areas reveals a much greater diversity of rock types than was previously known. The geology may therefore be more favourable as is evidenced by the existence of felsic and mafic flows, intrusions, and breccias. It is also important to note that the gold anomalies extend well into the Aroostook-Matapedia Subzone.

The gold occurrences in the eastern half of the map area are poor geophysical targets and to date, only prospecting of road and stream exposures has been successful in locating gold mineralization. This has led to an excessive reliance on traditional B-horizon soil sampling over vast areas, an unreliable exploration tool in heavily glaciated terrains. Systematic basal-till sampling over geologically favourable zones, while significantly increasing exploration costs, may be the most effective method of delineating auriferous zones in the absence of outcrops.

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PRECIOUS-METAL AND GEOLOGICAL INVESTIGATION OF THE CHARLO RIVER AREA

G.R. Philpott, MDA Project Geologist

The Charlo River area is situated in northeastern New Brunswick and is underlain predominantly by rocks of the Silurian Chaleurs Group. The area was chosen for investigation because it may have potential for "Carlin-Type" sediment-hosted gold deposits (Table 1).

Field mapping was performed at a scale of 1:10 000 over 450 square kilometres in NTS map areas 21 O/10, 21 O/15, and 21 O/16 (Figure 4). Many new outcrops have been exposed as a result of forest-cutting activities since the last mapping campaign (Irrinki 1976; Constable 1974a, b).

There are four main rock groups under investigation in the area: (1) black and green cherts and slates interbedded with mafic lapilli tuffs of the Ordovician "Goulette Brook formation" (Irrinki 1976) are overlain with apparent conformity by; (2) a thin unit of Ordovician lithic wacke, calcareous mudstone and minor crystalline limestone similar to the Grog Brook Group of St. Peter (1978). This unit is, in turn, conformably overlain by (3) thin-bedded limestone and calcareous shale of the Upper Ordovician to Lower Silurian Matapedia Group. The Matapedia Group is conformably overlain by (4) the shallowing-upward Silurian Chaleurs Group that consists of calcareous and noncalcareous, micaceous siltstone and nodular fossiliferous limestone, and amygdaloidal mafic volcanics, lapilli tuffs, and minor felsic lapilli tuffs.

Mafic and felsic plutonic rocks intrude all of the supracrustal units. Contact metamorphic effects vary widely from one intrusion to another. Around some intrusions, noncalcareous sediments have been hornfelsed, and calcareous sediments have been converted to banded skarn (porcelanite). Host rocks surrounding other intrusions, however, are not visibly affected.

A new graptolite locality was discovered by L.R. Fyffe in a quarry located next to the New Brunswick International Paper Company road in the Popelogan Lake area. The graptolites, recovered from black slates of the "Goulette Brook formation", have been identified by John Riva of Laval University as:

1. Dicranograptus cf. ramosus (Hall)
2. Dicellograptus cf. sextans (Hall)
3. Pseudoclimacograptus scharenbergi (Lapworth)
4. Pseudoclimacograptus modestus (Ruedeman)
5. Climacograptus bicornis (Hall)
6. Dicranograptus furcatus (Hall)
7. Didymograptus serratulus (Hall)
8. Retiolitid sp.
9. Obolus sp.

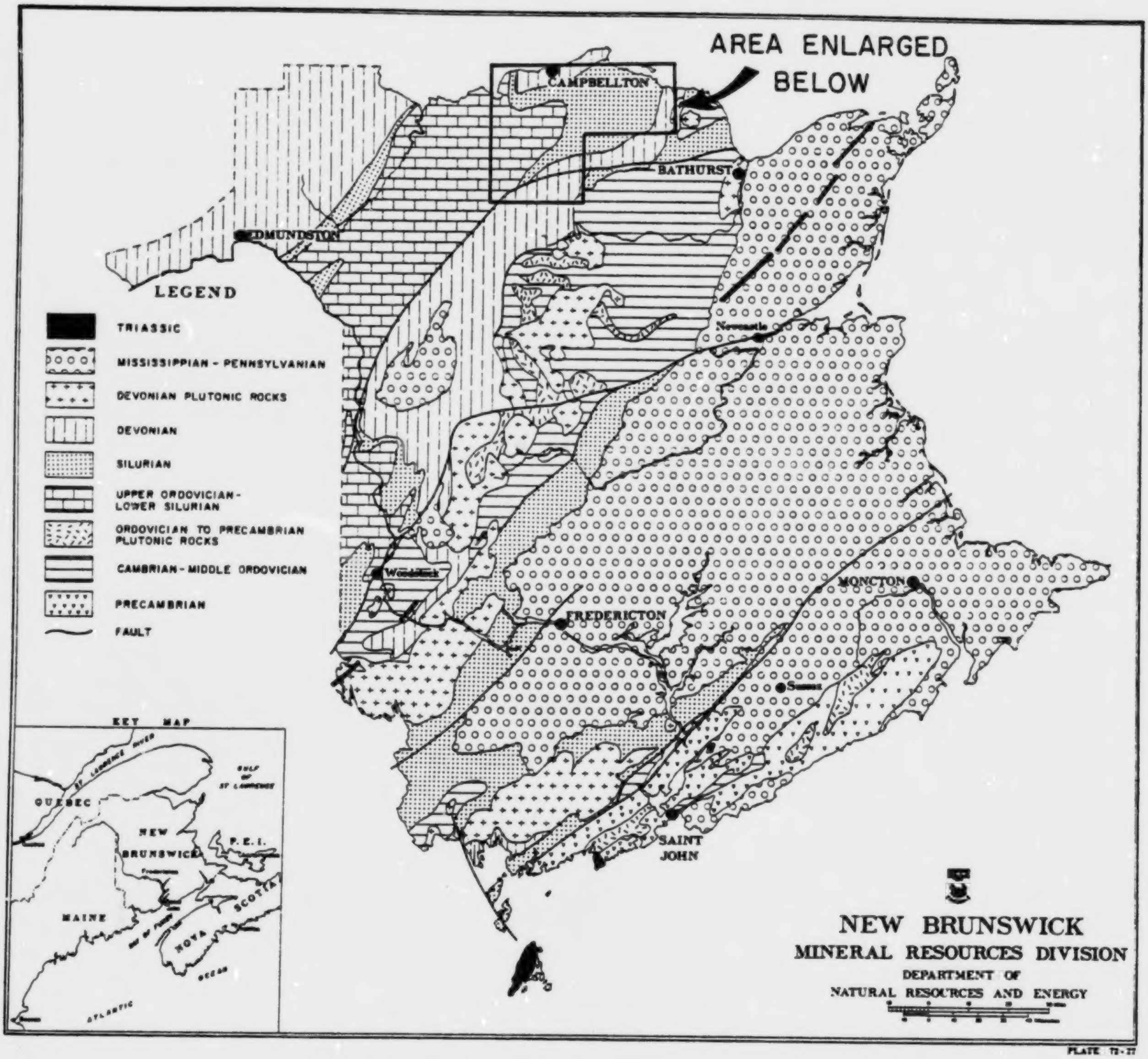
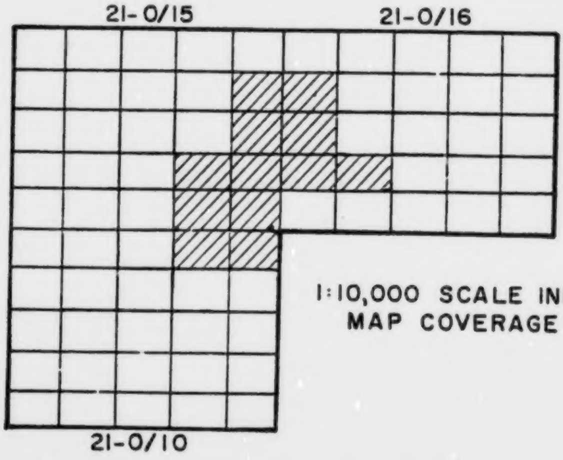


FIGURE 4. Geological map of New Brunswick showing location of NTS map areas 21 O/10, 21 O/15, and 21 O/16.



1:10,000 SCALE INDEX SHOWING MAP COVERAGE DURING 1987.

TABLE 1

COMPARISON OF CARLIN DEPOSITS TO CHARLO RIVER AREA ROCKS

	CARLIN DEPOSITS[1]	CHARLO RIVER AREA
HOST LITHOLOGY	Thinly bedded silty and shaly, carbonaceous limestone and dolomites, calcareous, carbonaceous shales and siltstones, and bioclastic limestone.	Limestone, calcareous shale, calcareous siltstone, nodular fossiliferous limestone.
IGNEOUS ROCKS	Intermediate to silicic dykes, plugs, domes, and stocks are present either in the deposit itself or within the district.	Mafic intermediate, and felsic dykes, plugs, domes, stocks, and sills are present; many are altered and and mineralized.
STRUCTURE	High-angle normal and/or strike-slip faults are present in all deposits. These faults are either pre-syn or post-ore. Thrust faults are present at some deposits, but do not seem to be the major controlling structure for ore deposition. Folds are present, both regionally and within deposits. In fact many deposits occur near the crust of regional antiforms.	Several northeast-trending major faults transect the area. Their sense of movement is not clear. The whole package of rocks has been regionally folded into a series of open to close folds with shallow plunge.
ALTERATION & OXIDATION	Hypogene alteration almost invariably includes early decalcification followed by silicification with jasper. All deposits are oxidized to some extent.	The region contains many hornfels and banded skarns in contact with plutonic rocks. Gossaniferous and sulphide-stained rocks are present locally.
MINERALOGY	Quartz veinlets and pyrite predominate. Other minerals present are jasper, cinnabar, stibnite, arsenopyrite, fluorite, barite, calcite, and various thallium and arsenic sulphides and sulfosalts.	Pyrite has been observed in all rock types in the Charlo River area while jasper has been identified in several mafic lapilli tuff outcrops.
TRACE-ELEMENT GEOCHEMISTRY	This deposit type is well known for its associated elements: Au, As, Sb, Hg, and Tl. Less common elements include: W, Te, Se, Cd, and F.	The area has been geochemically analysed for the same elements excluding Te and Cd. Results will soon be available.
DEPOSIT FORM	Two main types can be distinguished: 1. Jasperoidal quartz-veinlet type in fault zones. 2. Disseminated pod-like deposits with subordinate quartz veining.	Quartz-carbonate veining has been observed throughout the region.

[1] Bagby, W.C. and Berger, B.R. 1985. Geologic Characteristics of Sediment-Hosted, Disseminated Precious-Metal Deposits in the Western United States: Reviews in Economic Geology, 2, pp. 193-195.

This assemblage is characteristic of the Nemagraptus gracilis Zone of the Middle Ordovician (early Caradocian). Interbedded with the graptolitic slates are mafic lapilli tuffs that must also be of early Caradocian age.

In the same quarry, the author discovered fragments of a trilobite which were recovered from cleaved calcareous mudstone of the Grog Brook Group that overlies the graptolitic slates. R.K. Pickerill, of the University of New Brunswick, identified glabella of a trinucleid trilobite (Subfamily Cryptolithinae, Genus Cryptolithus. This genus ranges in age from Early to Late Ordovician and in eastern North America it is typically Early to Middle Ordovician (most commonly Middle Ordovician).

A representative suite of samples was collected from each map area for chemistry. One hundred and fifty altered and/or mineralized rocks were analysed for the following elements: Au, Ag, Cu, Pb, Zn, As, Sb, Ba, W, Hg, Tl, Bi, F, Fe, Mo, Sn, and Se.

To date geochemical information has been received on 57 of them. Seven of these samples contained greater than 10 ppb gold. Two Ordovician mafic lapilli tuffs, one containing jasper fragments, yielded 19 and 44 ppb gold. One gossaniferous Silurian sedimentary rock contained 18 ppb gold. Two intrusive rocks, a diorite with calcite veining and a siliceous feldspar porphyry, contained 12 and 34 ppb gold, respectively. Two felsic volcanic rocks from the Chaleurs Group assayed 15 and 25 ppb gold.

The results of this investigation will be published in 1988 as an open file report with accompanying geologic maps (scale 1:20 000).

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CONSTABLE, D. 1974a. Geology of map area L-3, St. Arthur, head of Charlo and Berry Brook (21 O/15). 1973. Scale: 1 inch equals 1/4 mile. Plate 74-131.

________ 1974b. Geology of map area L-4, parts of Popelogan River and Lake (21 O/15). 1973. Scale: 1 inch equals 1/4 mile. Plate 74-157.

IRRINKI, R.R. 1976. Geology of the Charlo (21 O/16) and parts of Campbellton (21 O/15), Tetagouche Lakes (21 O/9), and Upsalquitch Forks (21 O/10). Scale: 1:50 000. Plate 76-8.

ST. PETER, C. 1978. Geology of parts of Restigouche, Victoria and Madawaska counties, northwestern New Brunswick, (N.T.S. 21 N/8, 21 N/9, 21 O/5, 21 O/11, 21 O/14). New Brunswick Department of Natural Resources, Mineral Resources Branch, Report of Investigation 17.

A GEOLOGICAL STUDY OF THE HEATH STEELE MINES AREA, NORTHUMBERLAND COUNTY, PROVINCE OF NEW BRUNSWICK; (1986-1989) REPORT ON PHASE I & II ACTIVITIES

A.L. McAllister, P.F. Williams, J.G. Torrance,
C. Moreton, & J.A. de Roo - MDA

This study is part of a Canada-New Brunswick MDA covering geological investigations to be carried out in the vicinity of Heath Steele Mines. The objective of the project is to identify exploration targets by means of: (i) the compilation of all existing relevant geological and geophysical data; (ii) the establishment of the structural and stratigraphic relationships between the various sulphide bodies and (iii) the development and implementation of computer applications that will aid the investigation.

To date, the majority of the existing geological and geophysical data for the mine area has been compiled and plotted on common-scale map overlays. Diamond-drill-hole data (collar, survey, assay, rock coding, comments) have been stored on a microcomputer system at the mine site to facilitate automated plotting. A drill-core database has also been established to aid in the archiving and retrieval of drill-core data.

The detailed structural and stratigraphic mapping as well as drill-core reinterpretation in the "E", "B", and "B5" mineralized zones is being conducted by C. Moreton. Detailed mapping has involved the digging of several trenches in areas of minimal drilling and rock exposure. As a consequence of the "B5" zone area analysis, it has been proposed that the porphyritic rocks found on the mine property are approximately time-equivalent and are repeated to the south of the "B" zone area by second-generation (F2) folding. These folds plunge moderately to the west in the "B5" zone area in a pattern that is compatible with a pre-second deformation (D2) surface geometry that comprised recumbent folds.

A perspective block diagram of the main "B" zone is presented and shows patterns readily identified in the "B5" area immediately to the east. Structural and stratigraphic connection between these two areas of sulphide mineralization is implied.

The structural geologic mapping of the western half of the mine property is being conducted by J.A. de Roo, who has constructed a block diagram of the ACD zone in much the same fashion as that for the "B" zone.

In order to gain a better understanding of the stratigraphy in the vicinity of the major sulphide bodies, detailed magnetic and very low frequency (VLF)-EM surveys were conducted. Four individual grid areas were surveyed this year.

The removal of signal-aliasing effects was achieved by taking both magnetic and VLF-EM survey readings every twenty feet along the grid lines. Contoured surface plan maps of the filtered data collected from these surveys are being used to (i) locate other possible mineralized horizons; (ii) locate fault zones; (iii) locate possible lithologic contacts; (iv) extend the known strike extent of lithologic contacts mapped in areas of better exposure; and (v) identify areas of minimal overburden thickness in order to reduce trenching costs.

The detailed nature of these surveys has provided definition of anomalous zones, and a more accurate estimate of their shape and orientation. In particular, a computer program that produces VLF-EM pseudosections will be used in conjunction with magnetic profiles to estimate the attitude of the various geologic features.

In areas where a paucity of rock exposure and diamond-drill-hole data led to a poor understanding of the stratigraphic and structural relations, anomalous zones were explored by trenching. A total of approximately 3000 metres of trenches has been completed to date.

GEOSCIENCE COMPILATION PROJECT (MDA)

K.D.A. Whaley and Three-D Geoconsultants Limited completed their work on 21 O/8 in mid-1987. The twenty-five 1:10 000 maps showing all the geological, geochemical, and geophysical assessment data, are now being studied by the Geological Surveys Branch who will add the final geological interpretation. It is expected that these maps will be released in 1987. One other NTS sheet will probably be tackled in 1987-88.

Digitized 1:10 000 base maps are now available for NTS map areas 21 O/8, 21 O/10, 21 P/5, and those covering 21 O/9 are in preparation.

David Rose and Susan Johnson, working in the Sussex regional office, are continuing to develop a computerized mineral deposit file (page 45).

SULPHIDE DEPOSIT STUDY

R.R. Irrinki, Metallic Minerals Geologist

A comprehensive study of base-metal deposits in northwestern New Brunswick, undertaken by the NBDNRE Geological Surveys Branch, is in its third year. Confidential reports prepared on the Stratmat and Key Anacon sulphide deposits have fulfilled the main objective of delineating "potential ore". The Half Mile Lake deposit is currently under investigation and this work is expected to be finished by the end of 1988.

The Half Mile Lake sulphide deposit occurs 60 km (38 miles) southwest of Bathurst and 18 km (11 miles) west of the Heath Steele Mine. The deposit consists of at least three mineralized zones occurring as northeast-trending, en echelon lenses within a 3-km long sulphide-bearing sequence (Figure 5). These zones, from west to east, are known as Half Mile Lake (Texasgulf), Half Mile Lake (Conwest), and Half Mile Lake North. Reserves compiled on these three zones by D.A. Williams (Minerals and Energy Division mineral-occurrence files) in 1976 are presented in Table 2. The accuracy of these figures will not be known until the study is completed.

COMPUTER APPLICATION

In 1986, computer hardware (Sperry AT-IBM compatible) and software (GEOSTAT Systems International Inc., Montreal) were acquired to speed up the production of plans and sections necessary for reserve estimation. Four computer files were created for the Stratmat, Key Anacon, and Half Mile Lake deposits.

The first file, called "collar data", contains the three coordinates (longitude or easting, latitude or northing, and elevation) of the drill-hole collar, the initial orientation of the drill hole (azimuth and dip at collar), and the drill-hole length. The second, called "deviation data" records the change in orientation of the drill hole. Most drill holes deviate from their intended orientation and it is customary to measure this change at different depths by such methods as acid test, tropari, etc. Each drill hole will have several deviation readings, each consisting of a depth value, an azimuth value, and a dip value. Deviation data are not available for some holes.

The third file, called "interval data", contains assay values. It consists of hole number; depth of interval assayed; assay values for copper, lead, zinc, silver, and gold; NRC (net recoverable contents) value in $/ton; and NRC index. There may be several assayed intersections for any drill hole.

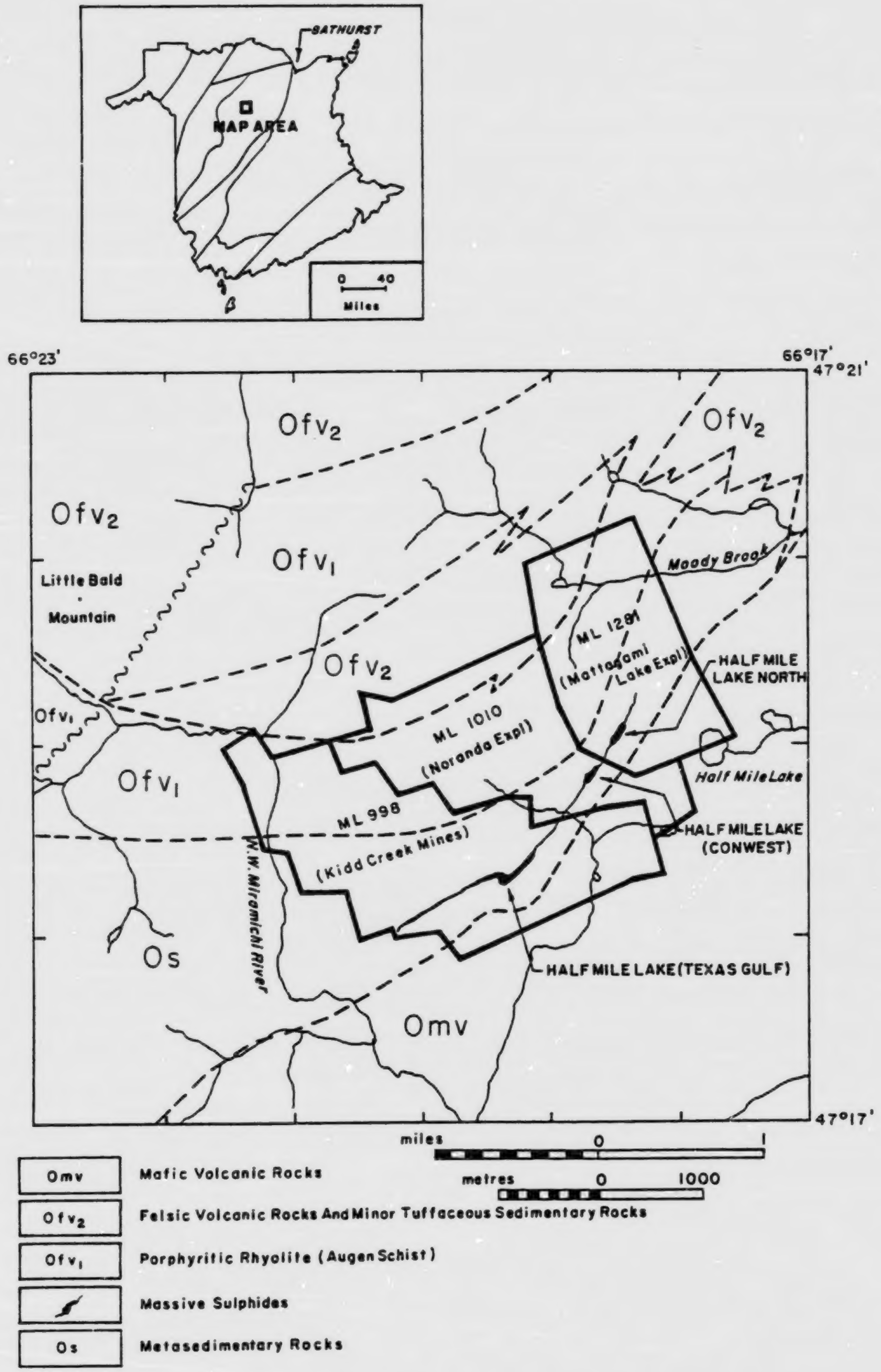


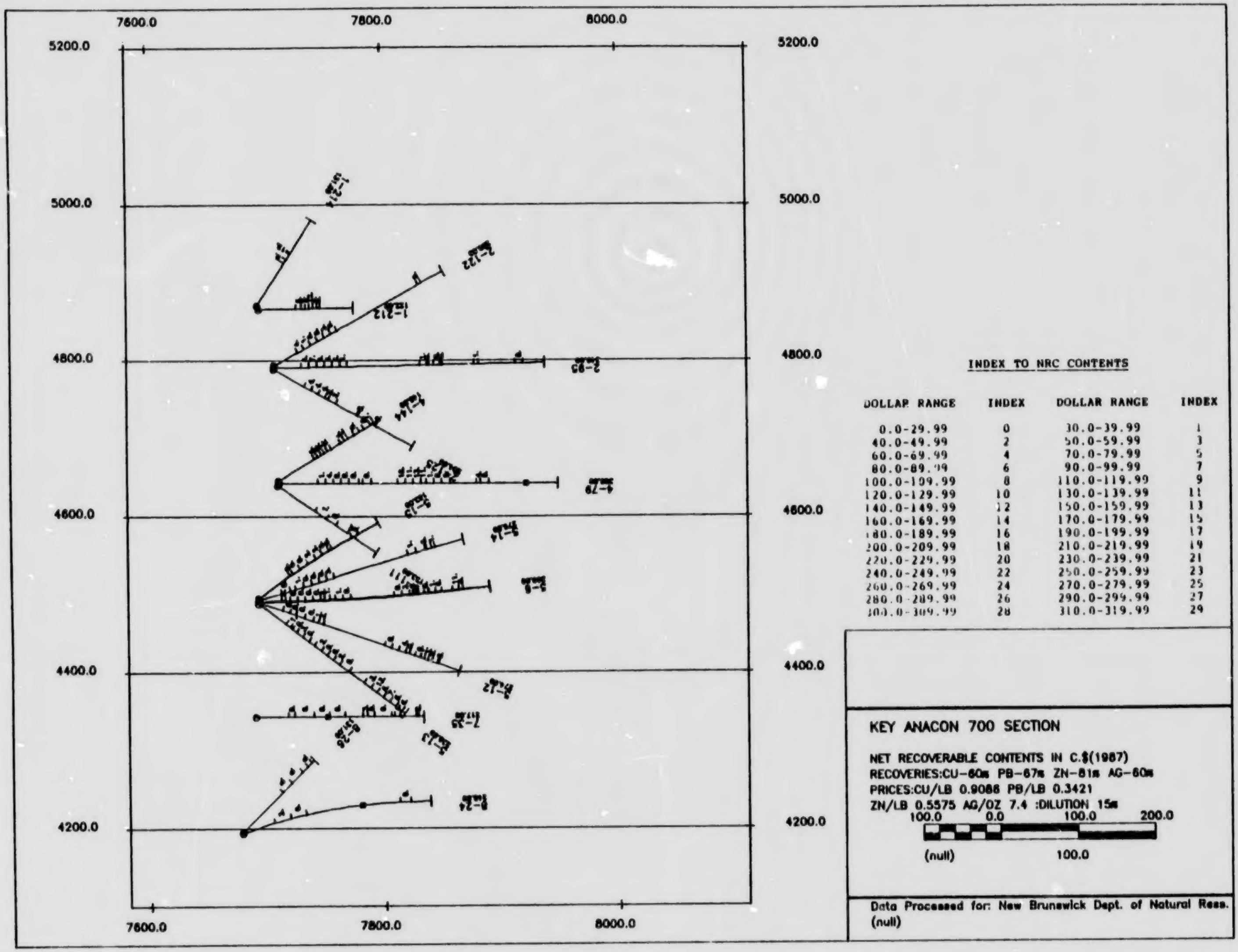
FIGURE 5. Geology around Half Mile Lake sulphide deposit.

The NRC value for each interval is calculated by using assay values, dilution factor (15%), recoveries for various metals (using recoveries at Brunswick No. 12 mine as a standard), and the current metal prices. Since NRC values vary widely ($0 to $300), they are grouped into thirty categories and are indexed 0 to 29.

The fourth file, called "geological data", contains the lithological data. The file consists of drill-hole number, two depth values (top and bottom contacts), name of the lithological unit (Omv, Ofv, Os, etc.), and description of the unit.

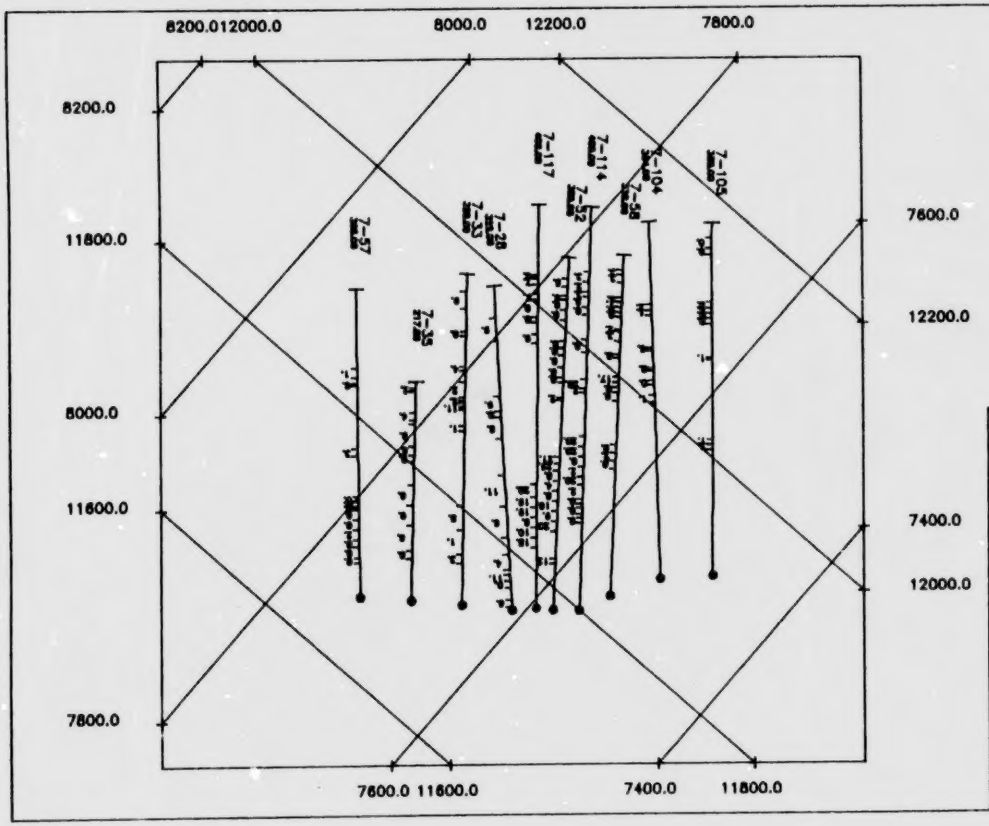
Both cross-sections and level plans are drawn by using the "SECT" program. Although any of the assay values could be used in sections and levels, only NRC indexes are shown in Figures 6 and 7. The lithological contacts are then overprinted on these sections and levels (Figures 8, 9). Sections in any direction can be displayed on the monitor by using PREPLOT. PENPLOT is used to generate sections on the NEC Pinwriter P5 printer and PRNTPLOT is used to generate sections on the Houston Instruments Plotter.

At present, the reserves are estimated manually by using a sectional method. In the near future, it is hoped to estimate the reserves by computer, using the SECTACAD and KRIGE3 programs. While SECTACAD estimates the reserves by sectional method, KR1GE3 estimates the reserves by 3-D kriging of blocks or grids.


7600.0
7800.0
8000.0
5200.0
5000.0
4800.0
4600.0
4400.0
4200.0
INDEX TO NRC CONTENTS
KEY ANACON 700 SECTION
NET RECOVERABLE CONTENTS IN C.$(1987)
RECOVERIES:CU-60% PB-67% ZN-81% AG-60%
PRICES:CU/LB 0.9088 PB/LB 0.3421
ZN/LB 0.5575 AG/OZ 7.4 :DILUTION 15%
100.0
0.0
100.0
200.0
(null)
100.0
Data Processed for: New Brunswick Dept. of Natural Ress.
(null)

DOLLAR RANGE	INDEX	DOLLAR RANGE	INDEX
0.0-29.99	0	30.0-39.99	1
40.0-49.99	2	50.0-59.99	3
60.0-69.99	4	70.0-79.99	5
80.0-89.99	6	90.0-99.99	7
100.0-109.99	8	110.0-119.99	9
120.0-129.99	10	130.0-139.99	11
140.0-149.99	12	150.0-159.99	13
160.0-169.99	14	170.0-179.99	15
180.0-189.99	16	190.0-199.99	17
200.0-209.99	18	210.0-219.99	19
220.0-229.99	20	230.0-239.99	21
240.0-249.99	22	250.0-259.99	23
260.0-269.99	24	270.0-279.99	25
280.0-289.99	26	290.0-299.99	27
300.0-309.99	28	310.0-319.99	29

FIGURE 6. Key Anacon 700 section.



INDEX TO NRC CONTENTS

DOLLAR RANGE	INDEX	DOLLAR RANGE	INDEX
0.0-29.99	0	30.0-39.99	1
40.0-49.99	2	50.0-59.99	3
60.0-69.99	4	70.0-79.99	5
80.0-89.99	6	90.0-99.99	7
100.0-109.99	8	110.0-119.99	9
120.0-129.99	10	130.0-139.99	11
140.0-149.99	12	150.0-159.99	13
160.0-169.99	14	170.0-179.99	15
180.0-189.99	16	190.0-199.99	17
200.0-209.99	18	210.0-219.99	19
220.0-229.99	20	230.0-239.99	21
240.0-249.99	22	250.0-259.99	23
260.0-269.99	24	270.0-279.99	25
280.0-289.99	26	290.0-299.99	27
300.0-309.99	28	310.0-319.99	29

KEY ANACON 700 LEVEL

NET RECOVERABLE CONTENTS IN C.$(1987)
RECOVERIES:CU-60% PB-67% ZN-81% AG-60%
PRICES:CU/LB 0.9086 PB/LB 0.3421
ZN/LB 0.5575 AG/OZ 7.4 :DILUTION 15%
100.0 0.0 100.0 200.0
(null) 100.0

Data Processed for: New Brunswick Dept. of Natural Ress.
(null)

FIGURE 7. Key Anacon 700 level.

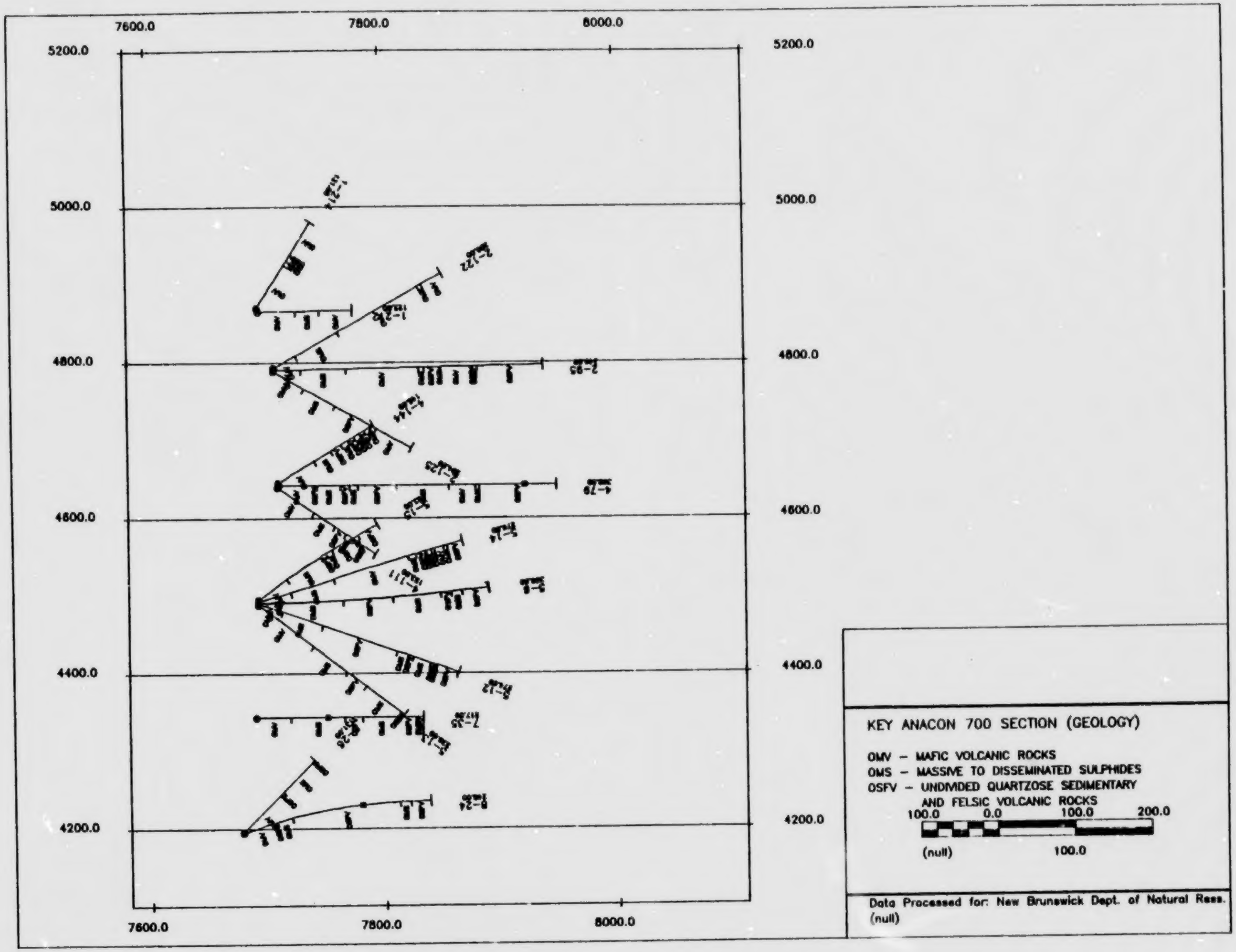

7600.0
7800.0
8000.0
5200.0
5000.0
4800.0
4600.0
4400.0
4200.0
KEY ANACON 700 SECTION (GEOLOGY)
OMV – MAFIC VOLCANIC ROCKS
OMS – MASSIVE TO DISSEMINATED SULPHIDES
OSFV – UNDIVIDED QUARTZOSE SEDIMENTARY AND FELSIC VOLCANIC ROCKS
100.0
0.0
100.0
200.0
(null)
100.0
Data Processed for: New Brunswick Dept. of Natural Ress.
(null)

FIGURE 8. Key Anacon 700 section (geology).

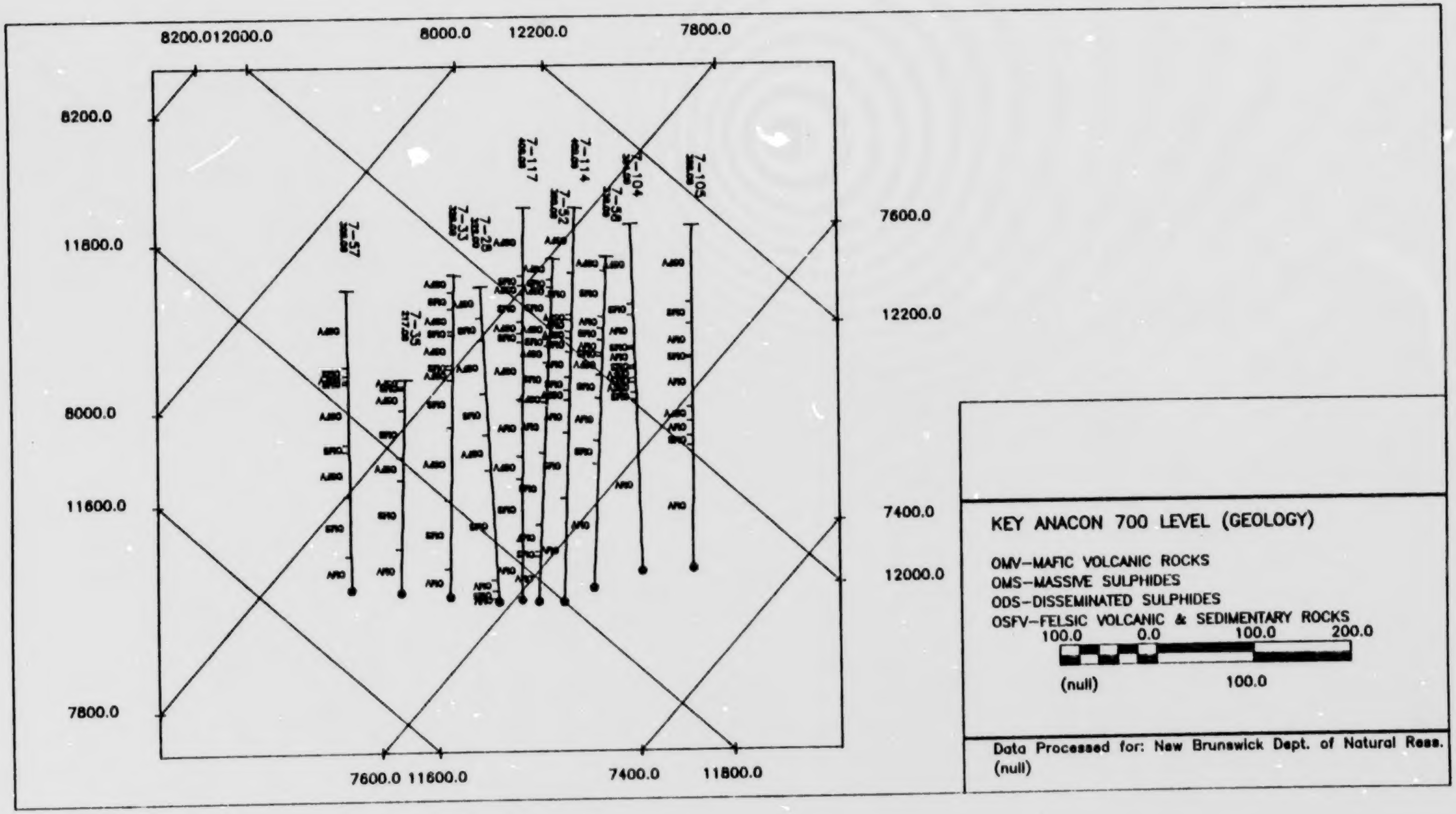


FIGURE 9. Key Anacon 700 level (geology).

TABLE 2

GEOLOGY AND RESERVES AT HALF MILE LAKE DEPOSIT

SULPHIDE ZONE (mining companies involved)	RESERVES	STRATIGRAPHIC SEQUENCE	MINERALIZATION AND OTHER CHARACTERISTICS
Half Mile Lake (Middle River Mining, Texasgulf, Kidd Creek Mines)	5.2 million tons (6.57% Zn, 2.49% Pb, 0.39% Cu) 1.2 million tons (2.00% Cu)	mafic volcanic rocks, sedimentary rocks and minor felsic volcanic rocks, massive sulphides, sedimentary rocks, porphyritic rhyolite, felsic tuff	pyrite-pyrrhotite-sphalerite-galena-chalcopyrite; sulphide zone plunges 35°N; zoning indicates tops toward the south
Half Mile Lake - Conwest (Bay Copper Mines, Conwest, Billiton, Noranda Exploration)	2.25 million tons (7.7% Zn, 2.5% Pb, 0.14% Cu)	mafic volcanic rocks, metaquartzite and greywacke, massive sulphides, porphyritic rhyolite and tuffaceous sedimentary rocks	pyrrhotite-sphalerite-galena-chalcopyrite; sulphide zone plunges 36°SW(?) zoning indicates tops toward the south
Half Mile Lake North (Golden West Minerals, Great Sweet Grass Oil, Keevil Mining Group, Mattagami Lake Exploration, Noranda Exploration)	0.87 million tons (4.95% Zn, 0.87% Pb; 0.39% Cu, 0.24% oz/ton Ag, 0.005 oz/ton Au)	mafic volcanic rocks, rhyolite tuff, massive sulphides, porphyritic rhyolite, and rhyolite tuff	pyrrhotite-pyrite-sphalerite-galena-chalcopyrite; sulphide zone plunges 30°N; zoning indicates tops toward the south

PUBLICATIONS 1987 - BATHURST REGIONAL OFFICE

PHILPOTT, G. 1987. Preliminary map. Bedrock geological compilation of parts of the Pointe Verte (21 P/13) map area. Scale: 1:20 000. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 87-51A.

PHILPOTT, G. 1987. Preliminary map. Bedrock geological compilation of parts of the (21 P12) Bathurst map area. Scale: 1:20 000. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 87-51B.

PHILPOTT, G. 1987. Preliminary geology map. Bradley Brook, Millstream River area (21 P/12). Scale: 1:2500. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 87-52.

PHILPOTT, G. 1987. Preliminary map. Bedrock geological compilation of the Rocky Brook area (21 P/12). Scale: 1:4800. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 87-53.

PHILPOTT, G. 1987. Preliminary geology map. Stephens Brook, Lavigne Brook area (21 P/12). Scale: 1:2500. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 87-54.

DAVIES, J.L. 1987. Arsenic-antimony-barium-gold content of stream and spring sediments: Tetagouche Lakes, west half (21 O/9W). Scale: 1:50 000. New Brunswick Department of Natural Resources, Mineral Resources Division, Map Plate 81-46h.

DAVIES, J.L. 1987. Arsenic-antimony-barium-gold content of stream sediments: N.W. Upsalquitch-28 Mile to Chisholm brooks, map area J-6 (NTS 21 O/11E). Scale: 1:25 000. New Brunswick Department of Natural Resources, Mineral Resources Division, Map Plate 81-47j.

DAVIES, J.L. 1987. Arsenic-antimony-barium-gold content of stream sediments: N.W. Upsalquitch-Nine Mile to Oxford brooks, map area K-5 (NTS 21 O/10W). Scale: 1:25 000. New Brunswick Department of Natural Resources, Mineral Resources Division, Map Plate 81-48j.

DAVIES, J.L. 1987. Arsenic-antimony-barium-gold content of stream sediments: Nine Mile and Oxford brooks, map area K-6 (NTS 21 O/10W). Scale: 1:25 000. New Brunswick Department of Natural Resources, Mineral Resources Division, Map Plate 81-49j.

DAVIES, J.L. 1987. Arsenic-antimony-barium-gold content of stream sediments: Forks of Upsalquitch River, map area L-5 (NTS 21 O/10). Scale: 1:25 000. New Brunswick Department of Natural Resources, Mineral Resources Division, Map Plate 81-50j.

DAVIES, J.L. 1987. Arsenic-antimony-barium-gold content of stream sediments: Charlo (21 O/16). Scale: 1:50 000. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 87-48.

DAVIES, J.L. 1987. Arsenic-antimony-barium-gold content of stream sediments: Nepisiguit Lakes (21 O/7). Scale: 1:50 000. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 87-49.

DAVIES, J.L. 1987. Arsenic, antimony, barium, and gold content of stream and spring sediments: Riley Brook East (21 O/3E). Scale: 1:50 000. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 79-50g.

DAVIES, J.L. 1987. Arsenic, antimony, barium, and gold content of stream sediments: Riley Brook area (21 O/3c,d,e,f). Scale: 1:20 000. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plates 84-8g, 9g, 10g, and 11g.

GEOLOGICAL SURVEYS BRANCH

SUSSEX REGIONAL OFFICE

ACTIVITIES OF THE SUSSEX REGIONAL OFFICE

A.A. Ruitenberg, Regional Geologist

The staff of the Sussex Regional Office consists of A.A. Ruitenberg (Regional Geologist), J.M. Mazerolle, Engineering Technician, and F.H. Kelly, Administrative Services Officer. S.R. McCutcheon, the former Assistant Regional Geologist, assumed the position of Regional Geologist in Bathurst. M.J. McLeod, S.E. Watters, D.G. Rose, S.C. Johnson, and W.W. Gardiner were employed under the Canada-New Brunswick MDA. M.J. McLeod accepted the additional responsibility of acting Assistant Regional Geologist. P.G. Chiswell was hired as a project geologist for the summer and fall field seasons.

CANADA-NEW BRUNSWICK MDA PROJECTS

M.J. McLeod and W.W. Gardiner completed detailed mapping and sampling of, respectively, the eastern and western Saint George Batholith. The different phases of the intrusive complex were delineated, and sampling for geochemical characterization was completed. The relationship between tin, tungsten, molybdenum, and gold occurrences with various intrusive phases was established, which accomplished the main fieldwork objective of the project. Laboratory investigations, preparation of maps, and a comprehensive report will be completed during the final stage of the project.

S.E. Watters completed detailed stratigraphic and structural mapping of the gold-bearing rocks in the Fundy Coastal Zone between Saint John Harbour and Black River. This included a detailed study of more than 200 diamond-drill cores from the Cape Spencer area. The relationship of gold mineralization, rock alteration, stratigraphy, and structure was established using a three-dimensional model constructed from drill-core and surface information. This accomplished the main fieldwork objective of the project. Rock sampling for detailed petrochemical, petrographic, and microstructural analyses and radiometric dating were completed. Laboratory investigation and map and report preparation will be completed during the final stage of the project.

D.G. Rose and S.C. Johnson continued work on the New Brunswick mineral deposits computer file. Design of the file was modified and about half the known mineral occurrences and deposits data from various reports were recorded on input sheets and entered into the computer. A limited amount of field checking was done on occurrences with insufficient information. The present project will be completed in 1988. Field checking and mapping geologic settings of various occurrences are planned for future updating of the file.

PROVINCIAL PROJECTS

S.R. McCutcheon completed his study of the Mount Pleasant caldera, which will be incorporated into a PhD thesis at Dalhousie University and a geological memoir of the Minerals and Energy Division. This study was of great interest, because it provided detailed information on the stratigraphic and petrochemical evolution of one of the few well-preserved Carboniferous calderas in the Appalachians.

P.G. Chiswell mapped and sampled the tills and glaciofluvial deposits overlying the gold-bearing Ordovician and Silurian sedimentary rocks in the Rollingdam area, Charlotte County. The map area cuts the surface trace of the major Honeydale Thrust Fault that extends to the southwest into the State of Maine.

A.A. Ruitenberg continued a comparative study of gold deposits and occurrences in the province. New data obtained from this investigation were incorporated into the computerized mineral deposits file.

In cooperation with I. Patel and G. Martin, A.A. Ruitenberg examined some recent deformational structures in bedrock and glaciofluvial and younger deposits in Saint John and Charlotte counties. Offsets of glacial striae were found locally along the Oak Bay Fault. Well-developed folds, normal and reverse faults were observed locally in glaciofluvial deposits and post-glacial varved clay deposits. Fault attitudes in these sediments are similar to regional bedrock faults in these areas. These structures differ from the more irregular slump folds and faults, resulting from subsidence produced by ice-cake melting, which occur in the area. Examination of neotectonic structures was initiated at the request of the Atomic Energy Control Commission. The ultimate objective is to produce an earthquake risk map for the Canadian Appalachians.

Geochemistry:

Dr. P.W.B. Friske of the Geological Survey of Canada (GSC) conducted a lake-sediment survey of southwestern New Brunswick from the Sussex office under the Federal-Provincial MDA. Sampling was done by using a helicopter with a specially designed steel cylinder in which to trap the soft sediment. A stream-sediment survey was conducted by the GSC in the same area. Publication of the results of a GSC stream-sediment survey along the Bay of Fundy delineated several areas with well-defined gold anomalies which generated considerable exploration interest.

Diamond-drill Core:

Diamond-drill core from several properties in southern New Brunswick was accepted including the Evandale and Black River copper-gold and the Mount Costigan base-metal-sulphide prospects. A new core-storage facility capable of storing 200 000 feet of drill core was completed on the site of the Sussex Regional Office last year.

Other Activities:

A gold metallogenic map of New Brunswick, compiled by S.C. Johnson and A.A. Ruitenberg, and a tin-tungsten-gold metallogenic map of the eastern Saint George Batholith, prepared by M.J. McLeod, were displayed at the Prospectors and Developers Association Meeting in Toronto in March. Final drafting of these maps was done by M. Lindsay. The gold metallogenic map will be published when funds are available.

A.A. Ruitenberg, S.R. McCutcheon, and M.J. McLeod prepared a CIM Field Trip Guide Book on the geology and ore deposits of the Mount Pleasant and Lake George areas which initially will be used for the first two-day field trip associated with the traditional annual student's night.

A field trip in the Pendar Brook gold zone was provided for the New Brunswick Prospectors and Developers Association. One-day field trips were provided for several prospectors and exploration geologists.

The regional geologist attended a meeting and field trip on neotectonic activity respectively in Quebec City and the north shore of the St. Lawrence River, east of the city. Earthquakes in this area are associated with growth faults that were initiated during the formation of the Cambrian-Ordovician Iapetus Ocean.

Assistance was provided to Robert Harris, MISP program co-ordinator, in the evaluation and modification of several applications for MDA projects.

SAINT GEORGE BATHOLITH PROJECT (EAST)

M.J. McLeod, MDA Project Geologist

Detailed field and laboratory investigations of the various intrusive phases and the economic potential in the eastern Saint George Batholith (Mount Douglas granite) was continued and a comprehensive report begun. To date the geological mapping (Figure 10), the geochemical sampling programs that include suites from the various intrusive phases and mineralized zones, and petrographic studies are essentially complete. These data and analyses from previous work are currently being compiled on a computerized data base. In addition, an Ar 40/39 dating program is ongoing. The temporal relationships between phases, particularly Units 1 and 2, and of the tin-tungsten mineralization must await confirmation by this program.

A series of intrusive events in the Mount Douglas granite is visualized as follows at the present. Coarsely crystalline rocks with variable amounts of fine-grained matrix (Units 1a and 1b) and porphyritic rocks (Unit 1c) represent initial intrusions. These units exhibit a mineralogy distinct from the rest of the Mount Douglas granite in that they contain, in addition to quartz + feldspar + biotite + opaques, sphene + hornblende +/- allanite. Unit 1 also displays a distinctive high magnetic signature on aeromagnetic maps reflecting relatively high magnetite content. Host rock inclusions and mafic xenoliths are common throughout this unit and it appears to be devoid of any tin-tungsten mineralization.

Subsequently, the bulk of the Mount Douglas granite was emplaced that is mostly comprised of high silica, seriate, biotite granite (Units 2a, 2b, 2c, 2d and 2e). Unit 2a is an early phase intruded by the rest of Unit 2. The later units exhibit gradational contacts and are distinguished by grain size and texture. Unit 2a is coarsely crystalline, contains abundant pegmatite and sporatic country rock inclusions, and mafic xenoliths. These features may indicate proximity to the roof of the pluton. All Unit 2 is essentially composed of quartz + feldspar + biotite + opaques and Unit 2a may contain minor allanite.

Unit 3 represents the latest phases of intrusions and is comprised of fine- to medium-grained equigranular granite (Units 3a and 3b) and porphyritic microgranite (Unit 3c). These units were emplaced as an elongate northeast trending series of intrusions from Red Rock Lake to Wirral (Figure 10). Unit 3c also occurs as small bodies and dykes throughout the rest of the Mount Douglas granite. Mineralogically, these units are similar to Unit 2 except that Unit 3a is slightly silica deficient. Most of Unit 3 is also discernable on radio-

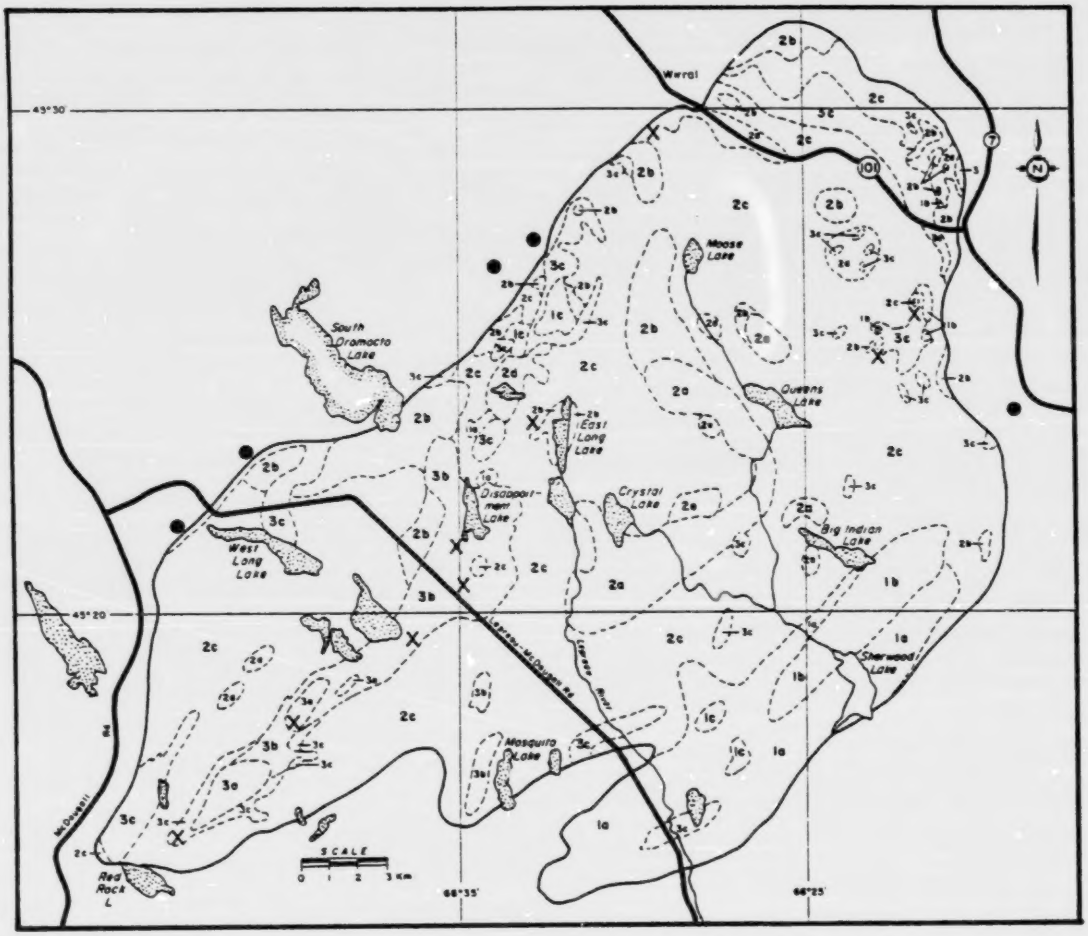


FIGURE 10. Geology of the eastern Saint George Batholith.

metric maps by exhibiting high Th and U radiometric signatures. The bulk of the tin-tungsten-bearing greisen and alteration zones are spacially and genetically related to this unit.

The two major subdivisions previously proposed (the Mount Douglas and Victoria Lake suites) appear to be invalid and variations from east to west merely reflect different intrusive phases. The linear distribution of the earliest remnants of the granite (Unit 1) and of many of the later phases (Unit 3) along projections of major basement faults, that occur to the east of the batholith, indicate a strong structural control on emplacement. Distribution and orientation of greisen and alteration zones indicate that they are also indirectly controlled by these major structural features and directly by the regional stress field at the time of emplacement. The most promising areas for economic tin-tungsten mineralization appear to be where axial parts of the mineralizing granites (Units 3a and 3b) are intensely fractured by intersecting structures of the regional stress field.

LEGEND

UPPER DEVONIAN

3c	Porphyritic biotite microgranite and aplite
3b	Red, medium- to fine-grained equigranular, biotite granite
3a	Grey, equigranular, biotite microgranite
2e	Microgranite and granophyre with abundant miarolitic cavities
2d	Fine-grained, equigranular to seriate, biotite granite with sparse quartz phenocrysts
2c	Medium-grained seriate, biotite granite with minor quartz and potassium feldspar phenocrysts
2b	Medium- to coarse-grained seriate, biotite granite; abundant coarser crystals of quartz and potassium feldspar locally with rapakivi texture
2a	Coarse-grained seriate, rapakivi, biotite granite
1c	Porphyritic, biotite microgranite with well-developed rapakivi texture; the matrix is commonly cryptocrystalline
1b	Porphyritic, biotite-hornblende microgranite and granite; rapakivi textures commonly well developed
1a	Coarse-grained to very coarse grained seriate, biotite-hornblende granite; rapakivi textures well developed

SYMBOLS

———	Road
---------	Geological contact
X	Major occurrences of tin- and/or tungsten-bearing greisen or alteration zones
●	Gold occurrences

The potential for gold mineralization within the Mount Douglas granite is still problematical. Till sampling surveys, particularly in the southeastern part of the granite, show several anomalies. Sampling was conducted of shear and alteration zones. Sampling in the contact aureole of the granite has reaffirmed the potential for gold mineralization in this environment.

SAINT GEORGE BATHOLITH PROJECT (WEST)

W.W. Gardiner, MDA Project Geologist

Geological mapping, geochemical sampling, and economic evaluation of the western Saint George Batholith is continuing. The geological map is preliminary (Figure 11). Several new intrusive phases have been recognized and contact relationships between most phases have been defined. Temporal relationships are, therefore, in part assumed. Samples have been submitted for Ar 40/39 dating but results have not been received.

Unit 1 is the Bocabec Complex; it is comprised of gabbro, diorite, and granodiorite (Unit 1a) and quartz monzonite to granite (Unit 1b). The gabbro is locally layered and commonly grades irregularly from ophitic gabbro to diorite. It is sequentially cut by granodiorite, quartz monzonite, and diabase dykes. The complex has now been extended much further to the east than previous mapping indicated. It is intruded by Unit 5 (Utopia granite), but its relationship to Units 3 and 4 is unknown at present.

Unit 2 is assumed to be the next oldest granite. Unit 2a is a grey, medium-grained biotite granite that locally contains 1-2% garnet and minor muscovite. Unit 2b is similar but does not contain garnet. Available analyses indicate that Unit 2 is one of the more sodic granites in the map area. This unit is characterized by its low magnetic susceptibility relative to surrounding units. It is in fault contact with Unit 3a to the west but is cut by Unit 3b to the east. It is also cut by late-stage dykes associated with the Beech Hill-type stocks and the Mount Pleasant caldera.

Unit 3a is a pink, coarse-grained, porphyritic (megacrystic biotite-hornblende granodiorite; Magaguadavic granodiorite). This unit is poorly exposed due to deep weathering. It varies to a seriate, biotite-bearing phase. It has not been seen in contact with the other intrusive rocks except Late Devonian - Carboniferous porphyry dykes. Unit 3b is a grey, medium-grained porphyritic biotite granodiorite, commonly with rapakivi textures. It has a much higher mafic content than Unit 3a (10-12% mafic minerals as opposed to 5-7% in Unit 3a). This mafic content is highest in proximity to hornfelsed metasediments. Unit 3b intrudes Units 1a and 3b in the South Oromocto Lake area. Units 3a and 3b are characterized by distinctly high magnetic features on the aeromagnetic maps and frequently contain 1-2% disseminated magnetite.

Unit 4 is a pink, medium-grained biotite granite. This is a poorly exposed unit in a area of low relief and its relationship to the other units is presently unknown.

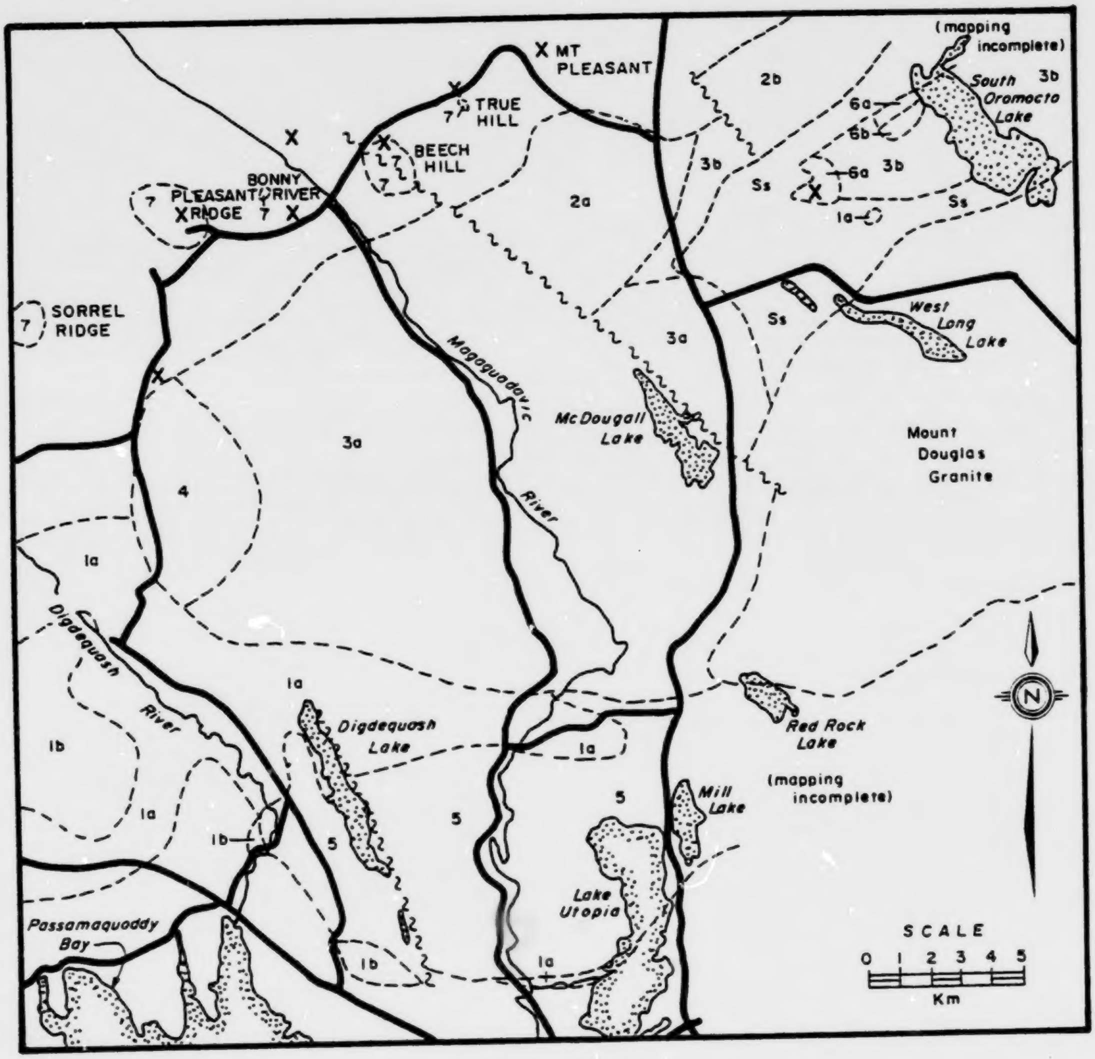


FIGURE 11. Geology of the western Saint George Batholith.

The Utopia granite (Unit 5) is a very uniform pink to red, medium-grained equigranular biotite granite which has traditionally supported the granite quarrying industry in the St. George area. The textural uniformity of this unit is disturbed only by aplite dykes and rare xenoliths.

Unit 6 occurs as two small bodies to the west of South Oromocto Lake. Unit 6a is a pink, fine- to medium-grained, slightly porphyritic biotite granite and is characterized by pyrite disseminations (locally to 3% and up to 3 cm) and by pyrite fracture coatings. Unit 6b is a equigranular biotite microgranite. These units are very similar to two of the late stage intrusive phases of the Mount Douglas granite to the southeast.

LEGEND

UPPER DEVONIAN

7	Pink, equigranular to porphyritic biotite microgranite (Beech Hill-type stocks)
6b	Buff to pink, equigranular biotite microgranite
6a	Pink, fine- to medium-grained, slightly porphyritic biotite granite
5	Pink to red, medium-grained, equigranular biotite granite (Utopia granite)
4	Pink, medium-grained, equigranular biotite granite
3b	Grey, medium-grained, porphyritic, biotite granodiorite, rapakivi texture common
3a	Pink, coarse-grained, porphyritic, biotite-hornblende granodiorite (Magaguadavic granodiorite), locally seriate

LOWER TO UPPER DEVONIAN

2b	Grey, fine- to medium-grained, equigranular biotite granite
2a	Grey, medium-grained, equigranular biotite +/- garnet, +/- muscovite granite
1b	Pink, fine- to medium-grained, equigranular quartz monzonite to granite (includes granite of the Bocabec Complex to west)
1a	Dark green, medium- to coarse-grained gabbro and diorite and grey, medium-grained equigranular granodiorite (includes gabbro of the Bocabec Complex to west)
Ss	Silurian metasedimentary rocks

SYMBOLS

━━━━━━	Road
- - - - - - - - -	Geological contact
∿∿∿∿∿∿	Faults
X	Major occurrences of tin- and/or tungsten-bearing greisen or alteration zones.

Unit 7 is comprised of several satellite plutons (collectively known as the Beech Hill-type stocks) along the northwest margin of the batholith. These stocks are equigranular to porphyritic biotite microgranites.

Economic minerals (tin, tungsten, copper, lead, and zinc) are primarily associated with Units 6 and 7. These minerals occur as disseminations or in greisens in the granites, and as disseminations in quartz veins cutting the surrounding hornfels. Gold values up to 0.35 oz/t have been reported from the latter type in the South Oromocto Lake area. Fluorite, molybdenite, and chalcopyrite have been found at several locations in the Utopia granite (Unit 5) and one location in the granite of the Bocabec Complex (Unit 2b). The fluorite is generally confined to miarolitic cavities in the granite or in quartz veins indicating a high level of emplacement for both units.

Mapping is presently in progress to the northeast of South Oromocto Lake where several gold occurrences have recently been found in the contact metamorphic aureole.

GOLD-BEARING ROCKS - BAY OF FUNDY COASTAL ZONE

S.E. Watters, MDA Project Geologist

The investigation of gold-bearing rocks along the Bay of Fundy Coastal Zone was in the midst of the third field season at the time of writing. Results of previous DNRE work can be obtained from the 1984, 1985, and 1986 Annual Review of Activities - project résumés.

The focus of work during the past year has been on the large amount of recently drilled core from gold-mineralized zones in the Cape Spencer area. A study of these cores shows details of the stratigraphy, structure, and alterations observed at a larger scale in outcrops between Mispec Beach and West Beach (Ruitenberg 1984; Watters 1985; 1986) (Figure 12). A three-dimensional model at a scale of 1:1000 was constructed from the drill-core data and surface information. Lithologies, major veins, rock alteration types, pyrite abundance, and structures were shown on wooden rods mounted in sheets of transparent plastic. The relationships of pyrite abundance, rock alteration, and structural geometry of major rock units were established using this model. A close correlation exists between pyrite abundance and gold content.

Tectonites, commonly altered and gold-bearing, and of similar origin to those described previously (Ruitenberg 1984; Watters 1985; 1986), have been studied in more detail. Several distinct types of tectonites were distinguished in the Precambrian granitoids and Cape Spencer redbeds within and near mineralized zones. The widely different appearances of these rocks reflect variations in intensity and style of deformation and alteration more than they reflect differences in original rock types. Detailed studies have shown that original rock types as different as granite and siltstone have been transformed to tectonites that are very similar in appearance. For example, the appearance of highly sheared and illite-altered granites approaches that of tectonites produced by shearing of highly veined and illitized sedimentary rocks, especially where feldspar is a vein constituent. These tectonites are mainly the result of pre- and/or early syn-D_2 and D_2 deformation as previously described (Ruitenberg 1984; Watters 1985; 1986). Extensive cataclastic and/or mylonitic zones are folded by D_2 or late-D_2 deformation.

It was found that in addition to illite, carbonate, and silica alterations (Ruitenberg 1984) a large halo of chlorite alteration at least tens of metres in thickness is associated with mineralized zones in the Cape Spencer area. This represents a potential exploration guide. Another guide, in terms of potential ore host, is the abundance of specular hematite either as veins or finely disseminated in sediment.

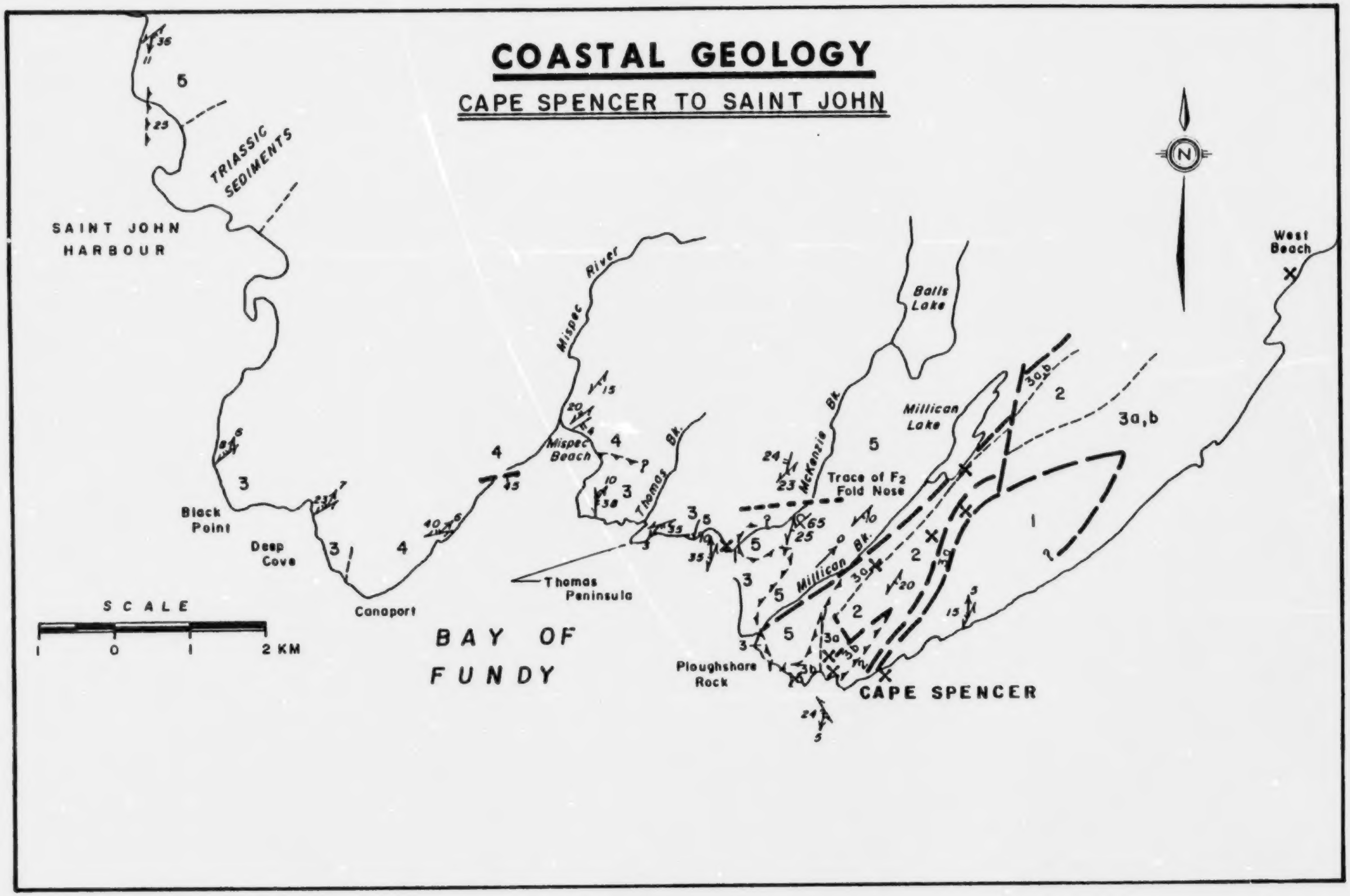


FIGURE 12. Coastal geology - Cape Spencer to Saint John.

LEGEND

CARBONIFEROUS

LANCASTER FM

5	Grey quartzose siltstone, sandstone, and conglomerate

BALLS LAKE FM

4	Red sandstone, slate, and quartz-pebble conglomerate

CARBONIFEROUS OR OLDER

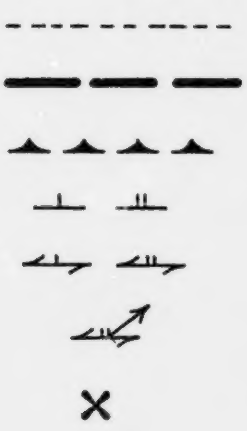
CAPE SPENCER REDBEDS

3	3a Greyish purple arkosic sandstone and conglomerate; 3b Greyish purple sandstone, siltstone, and conglomerate

PRECAMBRIAN and/or YOUNGER

2	Granodiorite and granite
1	Grey and greenish grey siltstone, sandstone, conglomerate, and basalt

SYMBOLS



geological contact

fault

thrust fault

bedding; upright; tops unknown

cleavage; S_1, S_2

D_2-stage fold with associated axial-surface cleavage

gold occurrence

It appears that pyrite, which is the main gold-bearing mineral, precipitated readily where specularite was available as the source of iron for pyrite formation.

Radiometric dating of significant rock constituents has been carried out this year. The main granite body that overthrusts purple sediments of the Cape Spencer redbeds at Cape Spencer (see Figure 12) has been dated by U/Pb content of zircons. Although this work is still in progress, the probable age of the granite has been established as 625 Ma +/- 15 Ma. Samples of the illite alteration associated with the Cape Spencer gold ores have been dated by $^{40}Ar/^{39}Ar$ isotopic analysis using a stepwise heating procedure. The two samples dated gave ages of illite formation of 273.9 Ma +/- 1.3 Ma and 283.0 Ma +/- 1.1 Ma, respectively. This earliest Permian age of the alteration is consistent with field evidence on the coast northwest of Cape Spencer where fossil-bearing Carboniferous sediments are similarly altered (Watters 1985).

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MINERAL DEPOSITS COMPUTER FILE

D.G. Rose & S.C. Johnson, MDA Project Geologists

Compilation and coding of mineral-occurrence data for the computer file was continued with assistance from W.W. Gardiner in April and May of this year. The original file structure has been modified, and work is progressing with an expected completion date in 1988. At that time, the file will have in excess of 850 records. To date, the file contains data on all occurrences in the NTS blocks indicated in Figure 13.

The modification of the file structure referred to above included the addition of two data fields with practical applications for prospectors and exploration geologists:

ASSESSMENT FILES - a listing of the most significant assessment reports related to each occurrence

STATUS OF GROUND - whether an occurrence is open or staked on a particular date

A limited amount of field checking of occurrences has been done, and has proved to be very useful where insufficient information was available or new developments have occurred. Follow-up to this project should therefore include field checking of occurrences - comprising sampling, mapping of their geological settings, and precise location measurements.

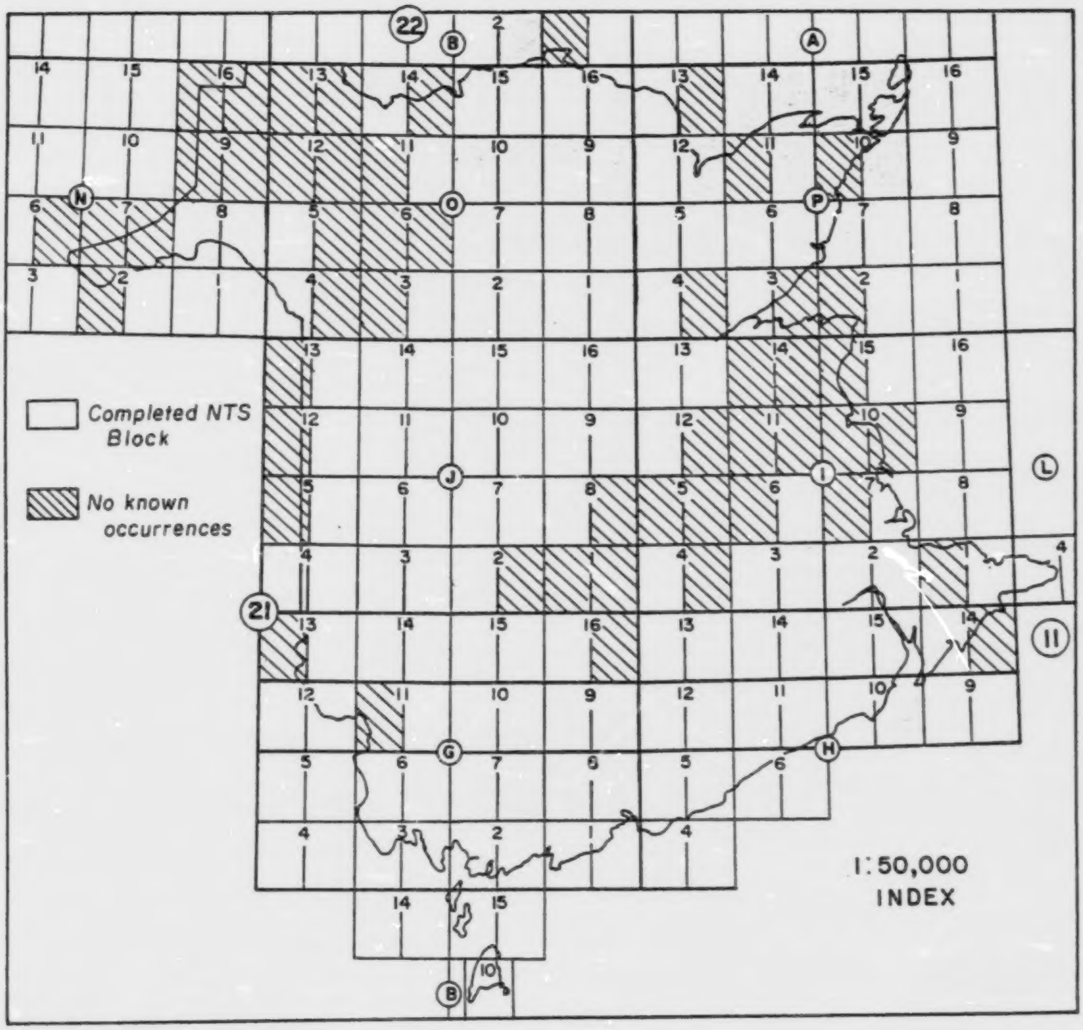


FIGURE 13. Index map for Mineral Deposits Computer File.

MOUNT PLEASANT CALDERA PROJECT

S.R. McCutcheon, Assistant Regional Geologist

Work on the Mount Pleasant caldera complex was completed and a draft report prepared. A simplified geologic map and column (Figure 14) summarize the stratigraphic relationships. The new stratigraphic terms presented below will be formalized in a future publication. Some of the major conclusions arising from this project are listed below:

1. Rocks in the study area can be separated into five sequences: a) pre-caldera, b) exocaldera, c) intracaldera, d) late caldera-fill, and e) post-caldera. The exocaldera, intracaldera, and late caldera-fill sequences together comprise the Late Devonian (? to Early Carboniferous) Piskahegan Group.

2. The exocaldera sequence contains, in stratigraphic order, the Hoyt Station Basalt, Rothea Formation, South Oromocto Andesite, Carrow Formation, and Bailey Rock Rhyolite.

3. The intracaldera sequence comprises the Scoullar Mountain Formation, Little Mount Pleasant Formation, Seelys Formation, and McDougall Brook Porphyritic Microgranite.

4. The late caldera-fill sequence includes the Mount Pleasant Porphyry and its associated breccias, unnamed "rapakivi" dykes, Big Scott Mountain Formation, and Kleef Formation.

5. The relative stratigraphic position of units in the exocaldera and intracaldera sequences is based on the following observations: a) the lower part of the Rothea Formation consistently contains about 1% prismatic "biotite". The only rocks within the caldera complex with this much prismatic biotite are volcanic clasts within sedimentary breccia, and a tuff unit near the apparent base of the Scoullar Mountain Formation; b) andesitic rocks only occur in the South Oromocto Andesite of the exocaldera sequence and the Scoullar Mountain Formation of the intracaldera sequence; c) the Carrow Formation contains clasts of Seelys Tuff; and d) the Bailey Rock Rhyolite, which overlaps the boundary between the two sequences, intrudes and/or overlies the Carrow Formation but is intruded by, or grades into, the McDougall Brook Porphyritic Microgranite.

6. The Mount Pleasant caldera formed as a result of eruption of the Rothea tuffs.

7. The unusual mineralogy of the Scoullar Mountain andesites (i.e., phenocrysts typical of basaltic rocks, in a matrix containing quartz and potash feldspar, and their association with sedimentary breccias) suggests that they are the product of magma mixing induced by caldera collapse.

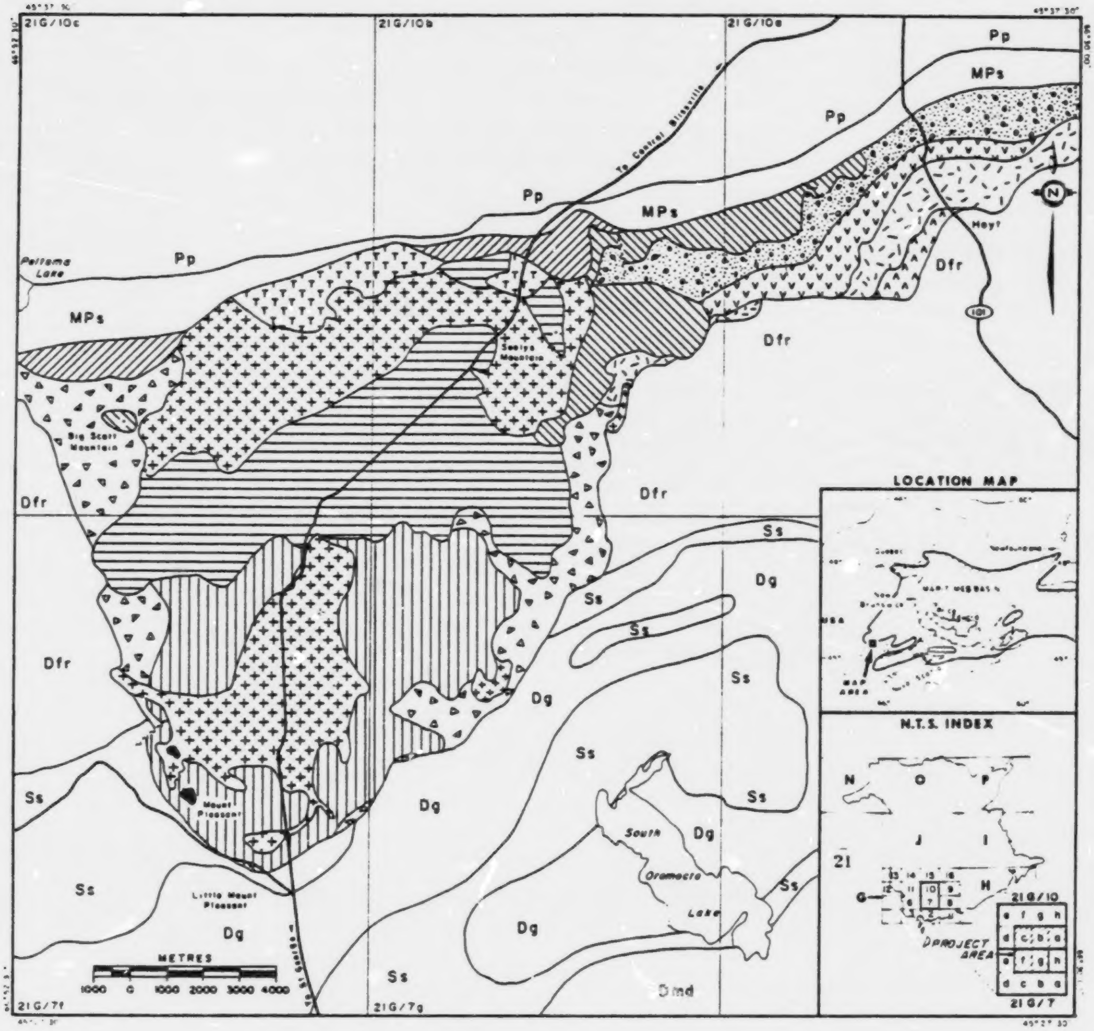
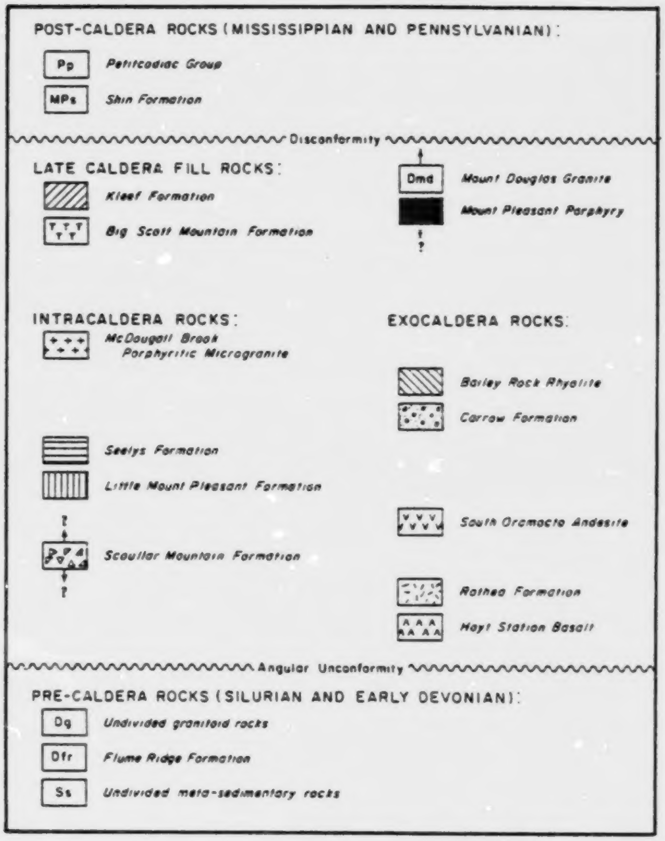


FIGURE 14. Geology of the Mount Pleasant caldera.

8. The McDougall Brook Porphyritic Microgranite was emplaced within the intracaldera volcanic pile, rather than beneath the caldera floor. Its level of emplacement, stratigraphic position, and location within the central part of the caldera together imply that late-stage resurgent doming occurred in the caldera.

9. Textural and mineralogical zoning is apparent in the Sophia and Juvenile tuffs (Rothea Formation), and is present, though less obvious, in the upper tuff of the Seelys Formation. This zonation reflects the inverse compositional zoning within the magma chamber prior to eruption.



10. Rocks of the late caldera-fill sequence are not part of the Mount Pleasant caldera-cycle because there was a considerable amount of erosion of intracaldera rocks prior to deposition of the fill sequence. This is indicated by the fact that fill rocks, in places, directly overlie the McDougall Brook Porphyritic Microgranite.

11. "Fossil" pumice shows that alteration associated with uraniferous rocks in the Mill Settlement area (exocaldera sequence) was effected prior to deep burial. Uranium minerals were most likely precipitated from fluids generated by, and associated with, emplacement of the Bailey Rock Rhyolite. Uranium-bearing rocks in the Duck Lake area (caldera margin setting) probably had a similar origin.

12. Mount Pleasant sits atop the "ring fracture zone" of the caldera. All but one of the four rock units mapped by Ruitenberg (1967) at the Mount Pleasant deposit have correlatives outside the mine area. The "brecciated metasediments" are assigned to the Scoullar Mountain sedimentary breccia. The "quartz-feldspar porphyry" that outcrops in the North Zone is

predominantly extrusive and correlative to the Little Mount Pleasant tuff, but that in the Fire Tower Zone crosscuts older rocks and may represent a vent area from which the Little Mount Pleasant tuff was erupted. The "feldspar porphyry" or "latite porphyry" is part of the McDougall Brook Porphyritic Microgranite. The "banded porphyry" or Mount Pleasant Porphyry has no lithologic correlative outside the Mount Pleasant area, but it is the near-surface equivalent of parts of the granite body beneath the mountain. Cooling and degassing of this granite magma produced the pipe-like breccia bodies (diatremes) that are associated with the Mount Pleasant Porphyry. This granite was also the source of the fluids that produced the tin-tungsten deposit.

SURFICIAL GEOLOGY AND GEOCHEMISTRY, ROLLINGDAM AREA

P.G. Chiswell, Project Geologist

Sampling was done on a two-kilometre grid spacing with a total of 140 samples being collected. Samples were taken from both the B and C horizons from hand-dug pits. Both the B- and C-horizon samples will be analysed for Cu, Pb, Zn, Ag, Mo, Sn, and W and the C-horizon samples will also be analysed for gold. Soil profiles were described to assist foresters in site classification.

Pebble counts to establish the lithologic composition of the tills will be carried out during the winter. The most common lithologies are metasedimentary rocks of the Cookson and Digdeguash formations and locally Devonian granitic and gabbroic rocks.

The area is covered mostly by basal till with a section of ablation till in the central-eastern portion (Figure 15). The southwest portion of the map area is highly drumlinized. The Magaguadavic and Digdeguash rivers were outwash channels during more than one episode of glaciation.

Gravel pits along the Digdeguash River show a good cross-section of the outwash with layers of reworked tills interbedded with well-sorted gravels and sands capped by a varved clay. Some pits show effects of post-Pleistocene deformation such as reverse faults, folds, and sand dykes.

The basal tills are mostly sandy gravels or gravelly sands with varied compactness depending on the clay content. The basal tills in the northern section are approximately one metre thick with bedrock exposures along sidehills and some streams. In the southern section, the basal tills commonly show drumlins, ridges, and knobs and are composed of poorly sorted gravels usually greater than three metres thick. In the areas between these features the tills are angular and compact and are generally about one metre thick. Basal tills in both areas vary from light olive-grey to a brown or yellow-grey.

The ablation tills are also gravels with poor sorting and a much higher frequency of boulders, a high amount of surface rock, and loose compactness. Often in the area of the ablation tills, morainal features are found which form ridges giving the area a hummocky topography. The ablation tills are generally thicker than the basal tills, usually exceeding two metres. The ablation tills range in colour from moderate yellow-brown to olive-grey.

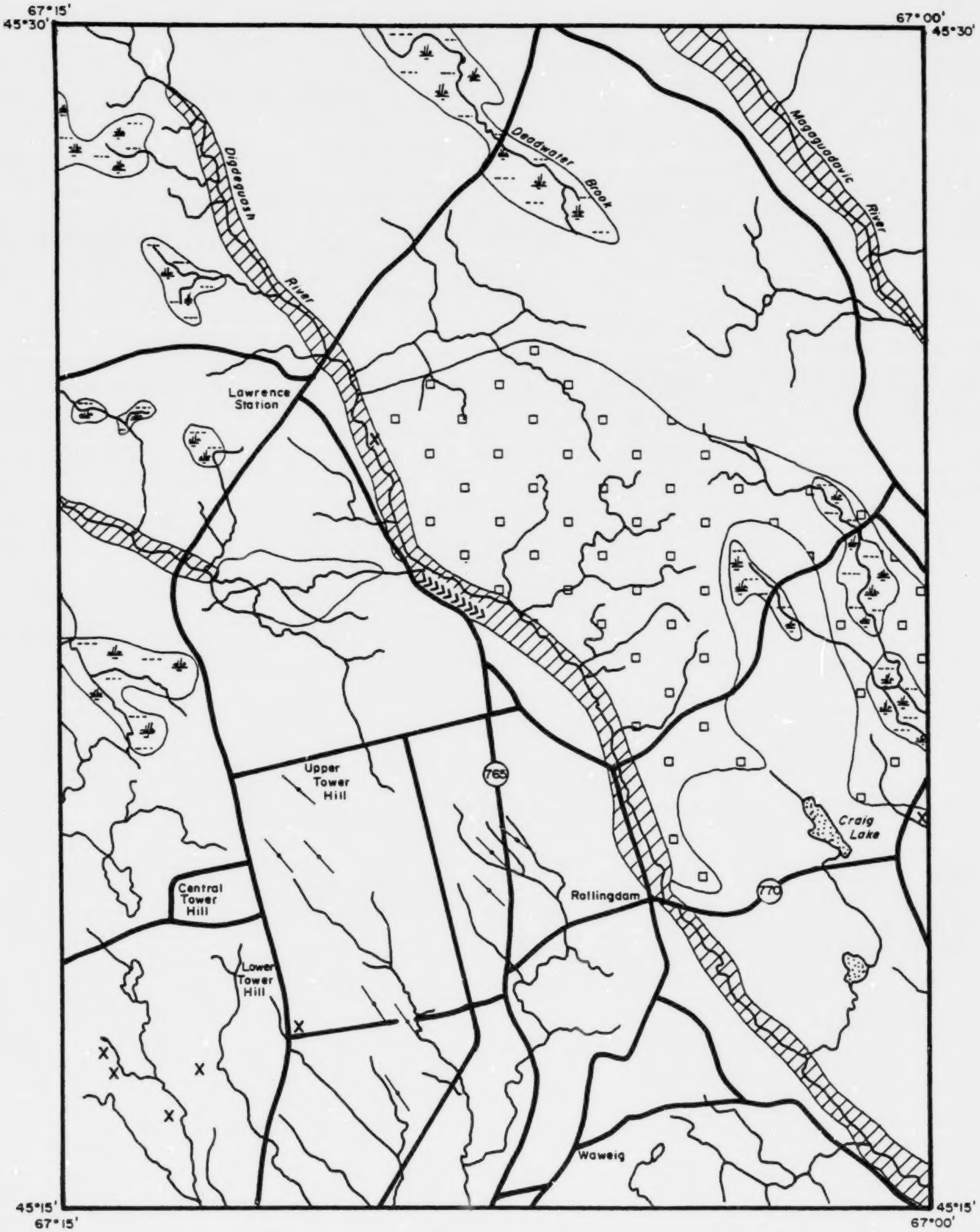


FIGURE 15. Surficial geology of the Rollingdam area.

LEGEND

▨	Glaciofluvial outwash - sand, gravel, and clay, well-stratified and well-sorted, minor alluvial deposits
⊡	Ablation till - boulders, gravel, sand, and clay, poorly sorted and poorly compacted; includes some sands and gravels
✱	Organic deposits - swamps, bogs, and wetlands
□	Basal till - moderate- to well-packed gravels with varying amounts of sand and clay; may include moraines and drumlins

SYMBOLS

—•—	Drumlins or fluted surfaces
━━━	Roads
>>>>>>>	Esker
X	Known mineral occurrences

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GEOLOGICAL SURVEYS BRANCH

GEOSCIENTIFIC SERVICES SECTION

ACTIVITIES OF THE GEOSCIENTIFIC SERVICES SECTION

L.R. Fyffe, Senior Geologist

The Geoscientific Services staff, located at the Hugh John Flemming Centre in Fredericton, consists of L.R. Fyffe (Senior Geologist), R.R. Irrinki (Metallic Minerals Geologist), G.W. Crouse (Core Librarian), V. Rinco (Geochemical Analyst), and B. Edney (Laboratory Assistant).

In addition to the regular staff activities, several projects were carried out by contract and summer personnel under the MDA. In central New Brunswick, H.E. MacLellan continued work on the Burnthill Project; A.G. Pronk mapped the surficial geology of map area 21 O/15 (Atholville), and parts of 22 B/1 (Oak Bay) and 22 B/2 (Escuminac) (page 63); and R. Wilson continued his geological mapping in the New Denmark area (page 57).

BURNTHILL GRANITE PROJECT

H.E. MacLellan, MDA Project Geologist

Field mapping has been completed in the Burnthill area and a complete set of maps has been published. The plate numbers and titles are listed in the publications of the Geoscientific Services Section on p. 76 of this report.

A paper entitled "Age and Genesis of granite-related W-Sn-Mo mineral deposits, Burnthill, New Brunswick, Canada" by R.P. Taylor, D.R. Lux, H.E. MacLellan, and F. Hubacher has been accepted for publication in Economic Geology. A paper on the lithogeochemistry of the Burnthill Granite is being prepared for publication. A suite of rock samples from the Burnthill pluton has been analysed for various metals and results will be released at a later date.

NEW DENMARK PROJECT

R.A. Wilson, MDA Project Geologist

Geological mapping at 1:20 000 scale in Victoria County continued during the 1987 field season with the completion of the western portion of NTS 21 O/3 (Riley Brook) and the eastern portion of 21 O/4 (Grand Falls) - (Figure 16). The area is underlain by lower Paleozoic sedimentary and volcanic rocks comprising portions of two tectonostratigraphic zones, juxtaposed along the Rocky Brook-Millstream Fault: the Aroostook-Matapedia Zone to the west and the Tobique Zone to the east.

The Aroostook-Matapedia Zone is underlain by calcareous and noncalcareous distal turbidity current deposits of the Matapedia Group (Unit OSm) and Grog Brook Group (Unit Og), respectively. The Upper Ordovician Grog Brook Group comprises interbedded argillites, siltstones, sandstones, and lithic wackes characterized by many primary structures typical of turbidites, e.g., convolute laminations and c-d Bouma sequences. The upper part of the Grog Brook Group overlaps the lower part of the Upper Ordovician-Lower Silurian Matapedia Group, so that they are partial time equivalents. The Matapedia Group consists primarily of thinly interbedded silty and argillaceous limestones and calcareous siltstones and argillites ("ribbon rock"). An unnamed unit (Unit OSu) of noncalcareous lithic wacke, grit, conglomerate, slaty argillite, and siltstone, similar in some respects to Grog Brook Group lithologies, has been mapped as separate from the Matapedia Group, as it apparently represents channel-fill deposition within the Matapedia Group.

The oldest rocks (Unit Ss) within the Tobique Zone are preserved in the core of the Hazeldean Anticline in the southwest portion of the map area. This unnamed unit typically consists of dark grey, fossiliferous, calcareous to noncalcareous siltstone with thin, grey-buff weathering, locally bioturbated sandstone beds and laminae, and grey, massive to parallel- or cross-laminated quartzose sandstone. Fossil dating has established a Llandovery (Early Silurian) age for these rocks. They are, therefore, synchronous with portions of other groups or formations mapped elsewhere in the region, e.g., the Matapedia Group, Perham Group, and Upsalquitch Formation, although the exact relations are unclear. This unit is succeeded by a thin (maximum 100 m) section of polymictic conglomerate (Unit Sc) and associated reddish maroon terrestrial feldspathic sandstones and siltstones reflecting a regressive transition related to regional uplift. An erosional disconformity apparently separates Unit Ss from Unit Sc.

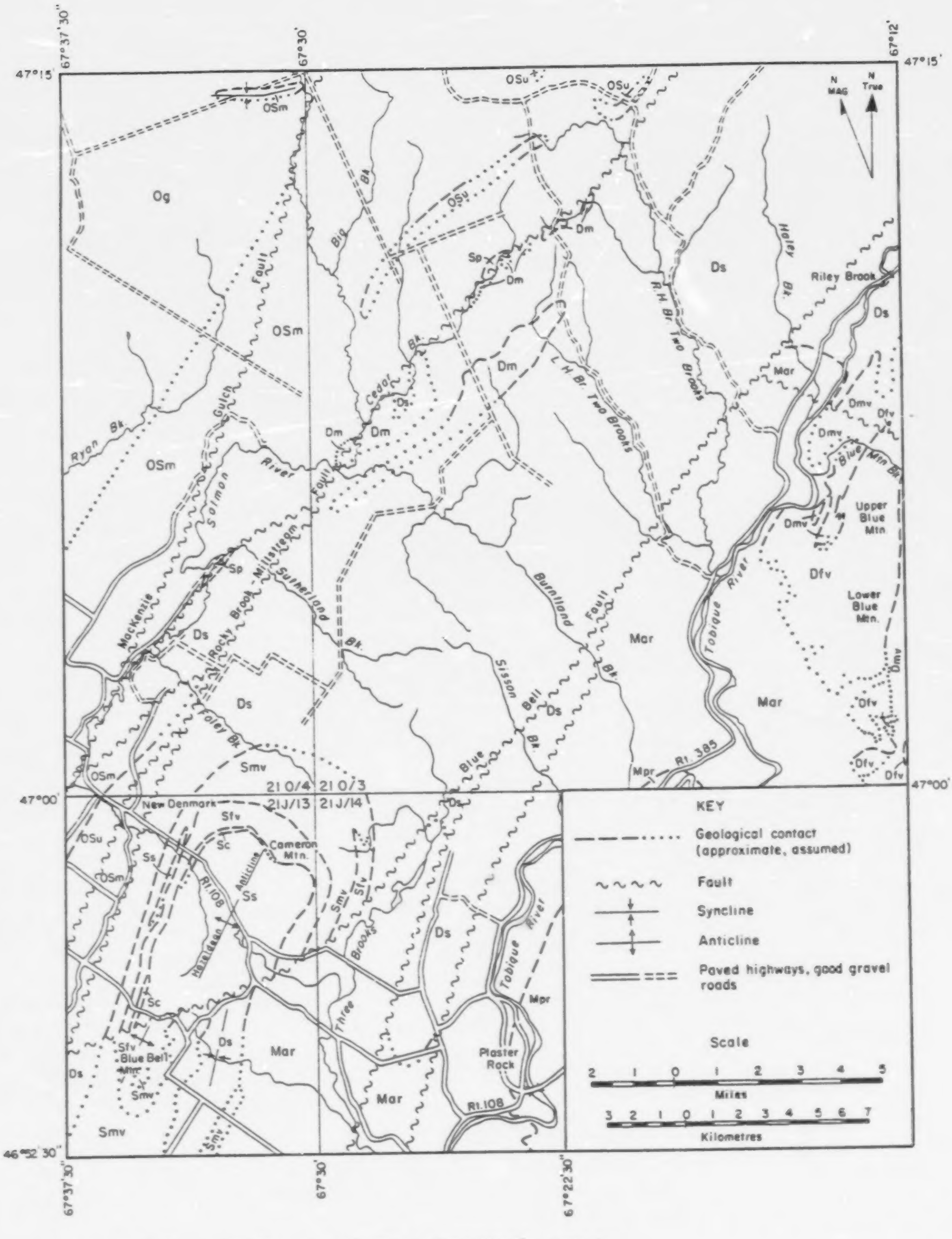

FIGURE 16. Geology of New Denmark area.

LEGEND

MISSISSIPPIAN

Mpr	PLASTER ROCK FORMATION Red and green shale, gypsiferous shale, shaly and nodular limestone, gypsum
Mar	ARTHURETTE REDBEDS Red sandstone, conglomerate, mudstone

DEVONIAN

Dm	Gabbro

LOWER DEVONIAN

	WAPSKE FORMATION
Ds	Siltstone, slate, fine- to medium-grained massive to parallel- or cross-laminated quartzose sandstone
Dfv	Maroon, massive to flow-banded, aphanitic to porphyritic felsic volcanic rocks
Dmv	Dark grey to green mafic volcanic rocks

SILURIAN

Sp	PERHAM GROUP(?) Grey, maroon or brown fossiliferous siltstone; pink, grey, or maroon limestone
	UNNAMED UNITS
Smv	Dark grey, dark green to purple-maroon massive to pillowed, locally vesicular mafic volcanic rocks
Sfv	Pink, buff, red, or orange aphanitic felsic volcanic rocks; minor tuffs and porphyritic rhyolite
Sc	Polymictic conglomerate, grading to feldspathic sandstone and siltstone
Ss	Dark grey, fossiliferous, calcareous to noncalcareous siltstone; grey quartzose sandstone

UPPER ORDOVICIAN-LOWER SILURIAN

OSm	MATAPEDIA GROUP Dark grey, silty to argillaceous limestone; calcareous shale and siltstone
OSu	UNNAMED UNIT Lithic wacke, pebbly grit, polymictic conglomerate, dark grey slaty argillite and siltstone

UPPER ORDOVICIAN

Og	GROG BROOK GROUP Interbedded parallel and convolute-laminated argillite, siltstone, and cross-laminated sandstone; grey lithic wacke and quartzite

Subaerial conditions persisted during the deposition of felsic volcanic rocks (Unit Sfv), comprising mainly pink, buff, red, or orange, locally flow-banded aphanitic rhyolite, with lesser porphyritic rhyolite and felsic pyroclastics. Coarse breccias and pyroclastics southeast of Cameron Mountain indicate the possible location of a vent system. Mafic volcanic rocks (Unit Smv), overlying Unit Sfv, are primarily submarine, characterized by an abundance of pillow basalts and by the presence of hyaloclastites and interbedded calcareous fossiliferous sedimentary rocks. Fossil dates from two sedimentary horizons range from Late Silurian to Early Devonian, suggesting that Units Smv and Sfv may be at least in part younger than their assigned Silurian age. Examination of larger volumes of fossil-bearing rocks may resolve the ambiguity in the age of the sediments and the host volcanic rocks.

Analysis of various trace-element abundances in basalts of Unit Smv indicates that volcanism took place in an extensional within-plate tectonic environment, which is consistent with conclusions derived elsewhere in the Maritimes.

An upper unit of felsic volcanic rocks (also labelled Unit Sfv) overlies and apparently interfingers with Unit Smv east of Cameron Mountain. It mainly comprises pink to reddish pink, massive aphanitic rhyolite, with minor flow-banded rhyolite, felsic to intermediate pyroclastics, and minor pillow basalt, quartzose sedimentary rocks, and volcanogenic conglomerate. Abundant coarse breccia exposed on a hill north of the Blue Bell Fault suggests that a vent may be located in this vicinity.

Two small "wedges" of limestone and calcareous fossiliferous siltstone (Unit Sp) crop out along Salmon River and Cedar Brook adjacent to faults, and have been tentatively assigned to the Perham Group pending identification of fossil samples. Similar slices of Perham Group lithologies are exposed along the Rocky Brook-Millstream Fault south of the map area.

The Lower Devonian Wapske Formation has the greatest areal distribution in the region. Felsic and mafic volcanic rocks (Units Dfv and Dmv, respectively) are dominant east of the Tobique River and the Blue Bell Fault, whereas only sedimentary rocks occur west of the Blue Bell Fault. Unit Dmv consists of dark grey, reddish maroon to dark green, massive, fine-grained, locally vesicular, amygdaloidal, or porphyritic flows. Unit Dfv comprises massive to flow-banded, aphanitic to porphyritic felsic rocks, typically maroon or various shades of maroon in colour. Little variety was noted throughout the area underlain by this unit, with the exception of some lapilli tuffs seen in float on the east side of Lower Blue Mountain.

Sedimentary rocks of the Wapske Formation (Unit Ds) include predominant thinly interbedded grey to green siltstones, slaty siltstones, and fine-grained quartzose sandstones, with lesser grey, thin- to medium-bedded, locally calcareous or fossiliferous (including fossil plant debris), massive to parallel- or cross-laminated quartzose sandstones. This unit overlies Unit Smv (on NTS 21 J/13 and 21 J/14), and Units Dfv and Dmv (on NTS 21 O/3), implying that Devonian sedimentary rocks to the west of the Blue Bell Fault extend stratigraphically lower in the section than those east of the fault, or, as suggested previously, that Units Smv and Sfv actually extend into the Early Devonian.

Small stocks of Devonian gabbro (Unit Dm) have intruded Unit Ds on NTS 21 O/3, just southeast of the Rocky Brook-Millstream Fault, and along the fault itself. No shearing was noted in these intrusions, hence they appear to post-date the latest movement on the fault. However, outcrop is scarce, and some of these intrusions are merely interpreted on the basis of aeromagnetic signatures.

The youngest rocks in the map area are flat-lying red sandstones, conglomerates, and mudstones of the Mississippian Arthurette Redbeds (Unit Mar), and shale, limestone, and gypsum of the Plaster Rock Formation (Unit Mpr). The Blue Bell Fault and two faults at North View have juxtaposed redbeds against Silurian and Devonian units northwest of Plaster Rock, whereas elsewhere along the lowland adjacent to the Tobique River they lie unconformably upon Devonian rocks.

The pre-Carboniferous rocks have been folded and cleaved by Acadian deformational events, producing a regional northeast structural trend. Anomalous trends within the Matapedia Group, e.g., near the northern margin of the map area, are apparently related to pre-cleavage, northwest-trending major folds that were then refolded during Acadian compressive deformation, producing northeast-trending, vertically plunging, minor folds typically observed in this unit. Folding in the Lower Silurian Unit Ss is typified by a large-scale, open, dome-like, doubly plunging structure (the Hazeldean Anticline), within which are numerous open, asymmetrical, doubly plunging minor folds. Structures in Devonian sedimentary rocks include gentle to open "parasitic" folds located on the limbs of major close to tight folds.

The area is transected by three major faults: 1) the McKenzie Gulch Fault; 2) the Rocky Brook-Millstream Fault, a major geofracture that forms the boundary between the Tobique and Aroostook-Matapedia tectonostratigraphic zones; and 3) the Blue Bell Fault, which terminates Silurian and Devonian units against Mississippian redbeds on NTS 21 J/13 and J/14, then strikes northeast, forming the western margin of the Plaster Rock Basin on NTS 21 O/3, before "becoming" the Mamozekel River Fault on NTS 21 O/6.

No pervasive alteration or mineralization, except for minor pyrite in volcanic rocks, was observed in the survey area. In those areas covered by provincial government stream geochemical surveys (only on NTS 21 O/3), the highest base-metal values are located at the head of Four Mile Brook, southeast of Lower Blue Mountain, with 458 ppm Zn and 206 ppm Pb. Mineral exploration has been limited within the survey area, and almost all activity has focused on Lower Blue Mountain. Canadian Occidental has had the most success in terms of anomalous metal values, with up to 184 ppm U, 1020 ppm Zn, and 325 ppm Pb in stream sediments from Four Mile and Blue Mountain brooks, and 245 ppb Au in heavy mineral samples. However, no alteration or mineralization was seen in outcrop. Geochemical analyses of arsenic, antimony, barium, and gold in stream sediments of the Riley Brook area (NTS 21 O/3) were released in October, 1987.

Possible environments favouring mineralization include:

1. Vent facies (breccias, etc.) in felsic volcanic rocks of Unit Sfv;
2. Coarse tuffaceous rocks seen in float on the east side of Lower Blue Mountain (Unit Dfv) suggest deposition proximal to an eruptive centre, which may be the source of high metal values on Four Mile Brook southeast of the mountain;
3. Au-Ag mineralization in possible shear zones within mafic intrusions (Unit Dm) or other rocks spatially associated with the Rocky Brook-Millstream Fault;
4. Ni, Co, and Platinum-group metals within mafic intrusions (Unit Dm).

Additional petrographic examinations, whole-rock and trace-element analyses of volcanic rock samples, and age and paleoenvironmental determinations on fossil collections will be carried out in preparation for the publication of ten 1:20 000 scale maps. These maps, with an accompanying comprehensive report, should provide improved basic geological data for this portion of the province.

SURFICIAL GEOLOGY AND TILL GEOCHEMISTRY - NORTHERN NEW BRUNSWICK

A.G. Pronk, MDA Project Geologist

In 1987, map area 21 C/15 (Atholville) and parts of 21 B/1 (Oak Bay) and 21 B/2 (Escuminac) were mapped and sampled with the able assistance of Mike Parkhill, Peter Hilder, and David Delaney. Procedures and methods were similar to those used for map area 21 O/10 (Pronk 1987).

The glacial record of this part of New Brunswick is similar to that of the Upsalquitch Forks area with strong striae and fluted forms indicating ice flow from west to east and a less erosive secondary ice flow toward the northeast. A distinct south-southeastward ice flow is recorded along the Bay of Chaleur by striae and fabrics. This flow precedes the northeastward flow pattern. The south-southeastward flow is restricted to the Campbellton Hills and Chaleur Coastal Plain (Physiographic Regions of New Brunswick, Rampton et al. 1984), whereas eastward-moving ice continued to occupy the Chaleur Uplands. Locally, younger southward striae were recorded on the Chaleur Coastal Plain.

Information recently recorded under the MDA projects (Rappol 1986; Bobrowsky et al. 1987; Pronk 1987) further complicates the glacial history of northern New Brunswick. Ice-movement indicators show that at different times and places, ice flowed in all possible directions. One older Quaternary feature in the area is a wave cut platform in the Campbellton-Dalhousie area at ±5 m above sea level, which is possibly of Sangamonian age (D.B. Grant, personal communication 1987).

Detailed work in northern Maine (Lowell and Kite 1986), northwestern New Brunswick (Rappol 1986) and Gaspé (Lortie and Martineau 1987; David and Lebuis 1985; Bail 1985) reveals similar complex patterns of glaciation. All these data somehow fit together in place and time and the following is just a first attempt, but timing is a major problem since there is a lack of dateable materials.

The absence of Canadian Shield erratics indicates that Laurentide ice did not reach the study area. Initially, westward-flowing ice in the eastern townships of Quebec indicates that local Appalachian ice built up before Laurentide ice crossed the St. Lawrence River (Lortie and Martineau 1987). The northern Maine-Notre Dame ice divide (Figure 17) was situated close to the New Brunswick-Quebec border. When Laurentide ice did cross the St. Lawrence River Valley it

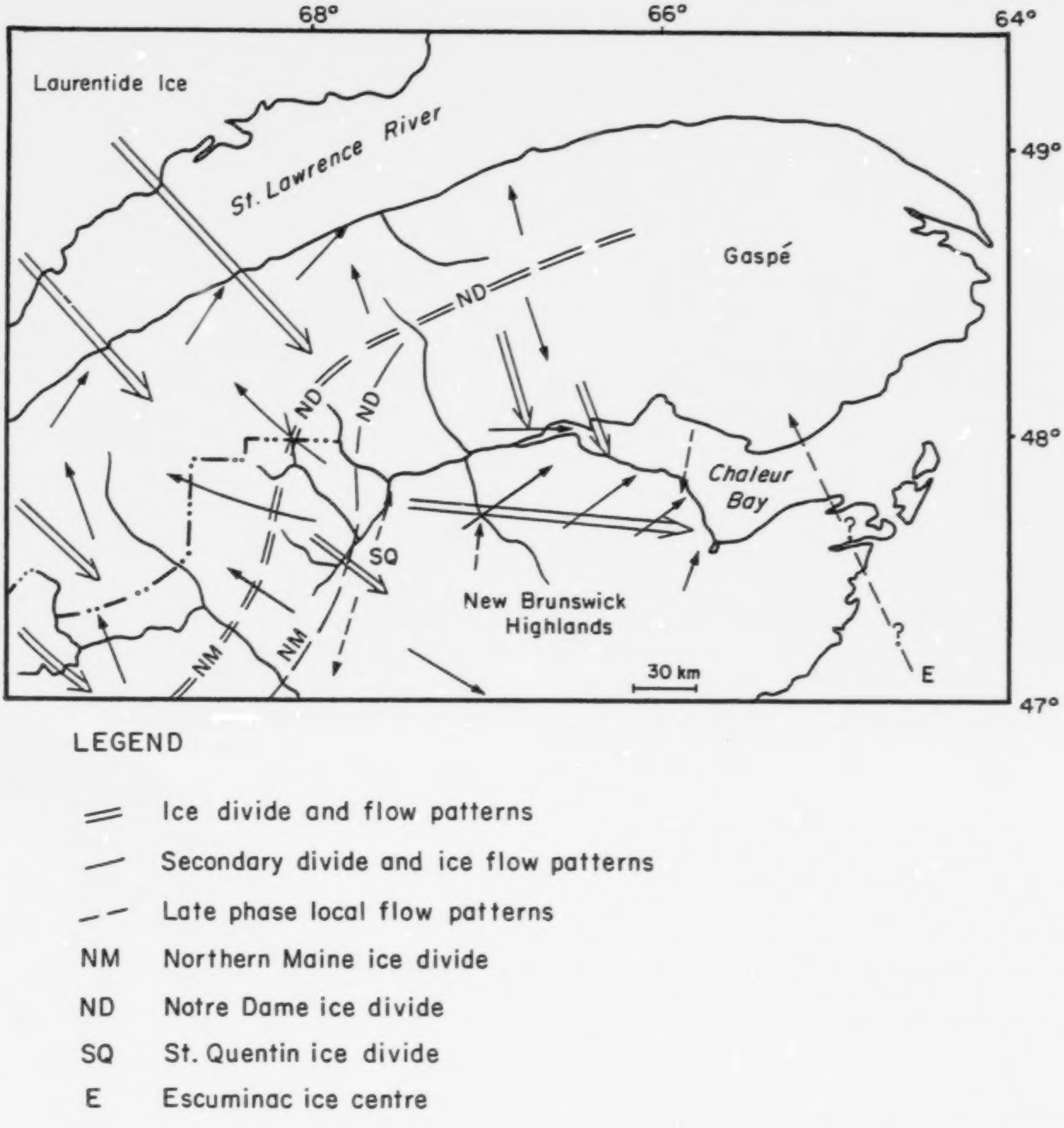

FIGURE 17. Compiled glacial history of northern New Brunswick and adjacent Quebec.

pushed the northern Maine-Notre Dame ice divide toward the southeast. During this phase, ice flowed from west to east across northern New Brunswick and was partly cold based (Pronk 1987), as was the case on the Gaspé peninsula which resulted in the deposition of local "monolithologic" tills (David and Lebuis 1985). Ice also flowed south-southeast from the Notre Dame Mountains across the Gaspé into the Bay of Chaleur area. In northern New Brunswick, this flow was restricted to coastal areas.

Secondary flow seems to be consistently in a northeast direction in most of the Chaleur Region (Jacquet Plateau, Coastal Plain, Campbellton Hills). Till fabrics indicate that most tills were deposited or reoriented during this flow phase.

Possibly at the same time, a calving bay was present in the St. Lawrence River estuary, a drawdown of ice into the St. Lawrence and a shifting ice divide (Figure 17) resulted in ice-flow reversal in southeast Quebec, northern Maine, and north-western New Brunswick (Lowell 1985; Rappol 1986). After the break-up of the Appalachian ice sheet, local ice centres (St. Quentin, Escuminac, New Brunswick Highlands, Chaleur Bay?) caused ice to flow in all possible directions. Recorded are radial flow off the St. Quentin plateau (Rampton et al. 1984), northward flow off the highlands, southward flow onto the Chaleur Coastal Plain, and northwestward flow onto the south shore of Gaspé Peninsula possibly under the influence of the Escuminac ice centre in Northumberland Strait (Bail 1985), although timing is a problem with the last correlation (Rampton et al. 1984).

Surficial geology and till geochemistry maps will be produced in a similar fashion to the Geological Notes Series P.M. 87-47, the release of which resulted in a minor staking rush in the Upsalquitch Forks area, although some anomalous areas have not received any attention to date. The results of this mapping and till geochemistry project have been presented at the AGS Symposium in Fredericton and at the 12th International Congress for Quaternary Research in Ottawa. Apart from the geochemical exploration aspect of the work, the spin-off product as a base for forestry research received a lot of attention.

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ORIGIN OF AMPHIBOLITES IN THE MIRAMICHI HIGHLANDS OF NEW BRUNSWICK

L.R. Fyffe, Senior Geologist

INTRODUCTION

The regional distribution of high-grade metamorphic rocks within the Miramichi Highlands of central New Brunswick is shown in Figure 18. These rocks mainly consist of psammitic and pelitic paragneisses, but abundant amphibolites and felsic orthogneisses occur in the Trousers Lake and Sisson Brook areas (see locations A and B, respectively on Figure 18). Considerable controversy exists concerning these rocks in that they have been interpreted to be either a high-grade metamorphic equivalent of the Cambro-Ordovician Tetagouche Group, or to be a Precambrian basement complex. In order to help resolve these conflicting interpretations, samples of amphibolites were collected for chemical analysis. Basalts from the Tetagouche Group in the Sisson Brook and Bamford Brook (see location C on Figure 18) areas were sampled to determine if they could represent protoliths for the amphibolites.

Amphibolites in the Trousers Lake area consist of both striped and unstriped varieties, whereas those in the Sisson Brook area are unstriped. Strong deformation and accompanying high-grade metamorphism have affected geological contacts in the central Miramichi Highlands to such a degree that it is difficult to determine the original nature of the relationships of the amphibolites to other units in the field. Although most contacts are now sheared and concordant, a cross-cutting amphibolitic dyke within psammite in the Sisson Brook area indicates that at least some of the unstriped amphibolites in that area are intrusive. An igneous and probable intrusive origin for the unstriped amphibolites of the Trousers Lake area is suggested by their similarity to those of the Sisson Brook area. Felsic orthogneisses, which exhibit lit-par-lit relationships with the unstriped amphibolites in both the Sisson Brook and Trousers Lake areas, are presumably part of this same intrusive complex. Banded iron formation appears to be interbedded with the striped amphibolites (Don Hattie, personal communication 1987) suggesting that they were derived from a volcanic protolith.

PETROCHEMISTRY

The amphibolites of the Trousers Lake and Sisson Brook areas are generally hypersthene-normative and possess Nb to Y ratios indicative of subalkalic igneous affinity (Figure 19). They display an iron-enrichment trend on an FeO versus FeO/MgO diagram, consistent with tholeiitic character. The striped amphibolites, on average, contain more MgO, CaO, and Cr, and less SiO_2, TiO_2, FeO (total iron), K_2O, P_2O_5, Ba, Rb, Sr, Y, Zr, Nb, and Ga than the average unstriped variety of either the Trousers Lake or Sisson Brook areas (Figure 20).

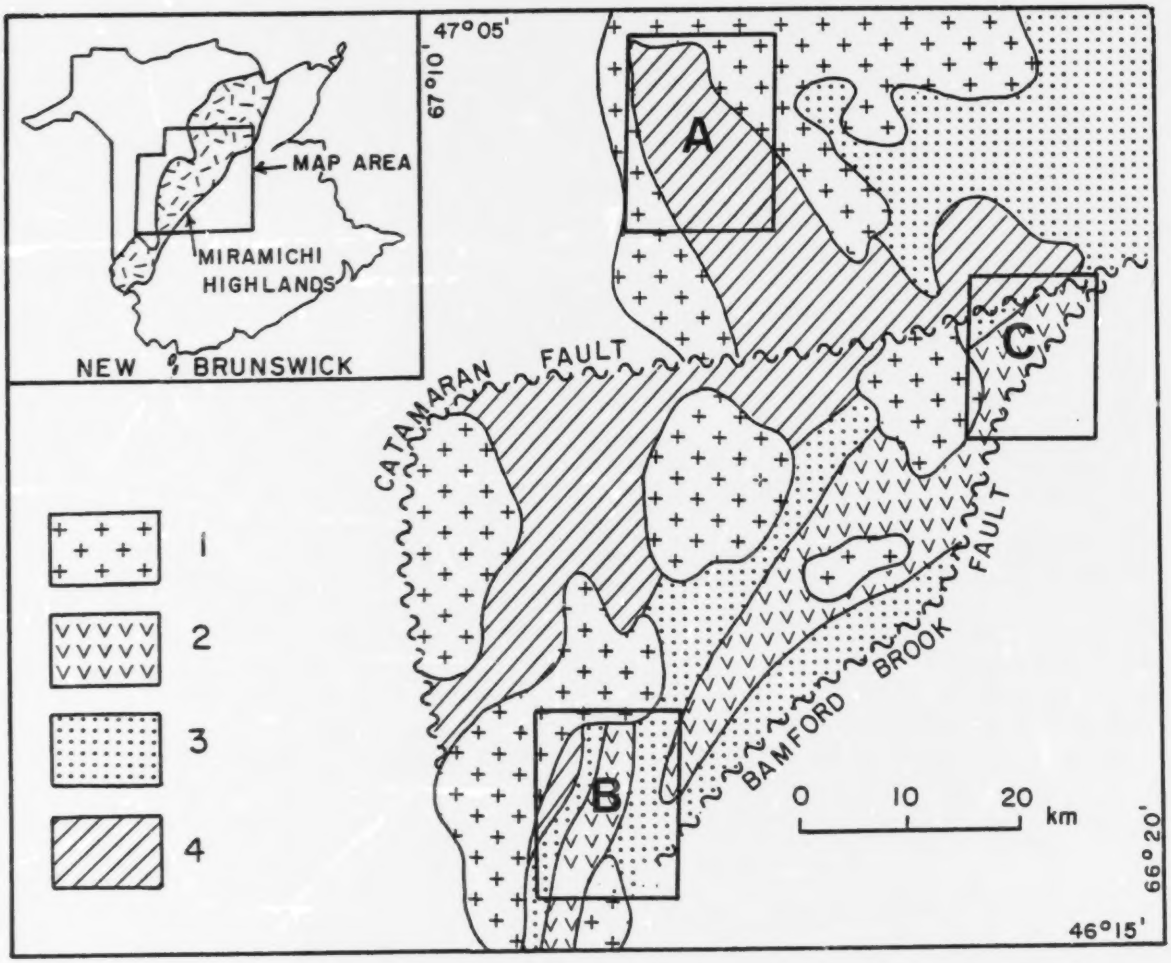

FIGURE 18. Index map for the Trousers Lake (A), Sisson Brook (B), and Bamford Brook (C) areas. Legend: (1) Devonian granite; (2) Ordovician volcanic and associated sedimentary rocks of the upper Tetagouche Group; (3) Cambrian to Early Ordovician quartzite and slate of the lower Tetagouche Group; (4) paragneiss and amphibolite, felsic orthogneiss, and augen granite.

On a Nb-Zr-Y diagram, most of the unstriped amphibolites of both the Sisson Brook and Trousers Lake suites cluster in the field of within-plate tholeiitic (WPT) or volcanic arc basalt (VAB) (Figure 21). An origin as VAB is unlikely as the samples of unstriped amphibolites contain too high a content of such trace elements as Zr, Nb, and Y. The striped amphibolites of

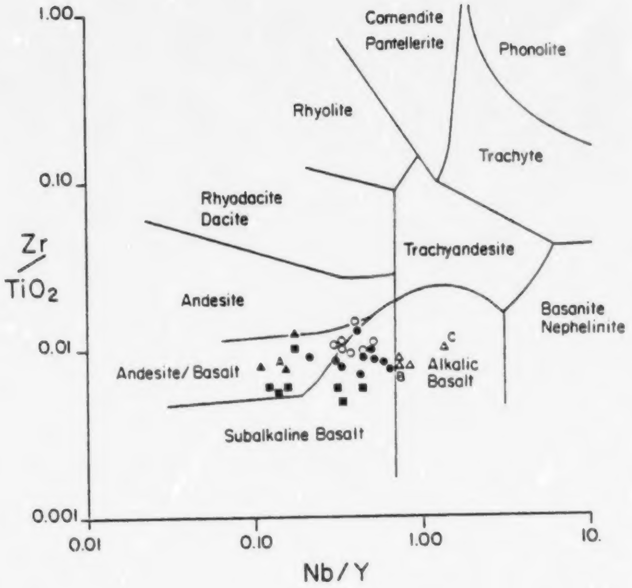

FIGURE 19. Plot of Zr/TiO_2 versus Nb/Y showing fields of common volcanic rocks (after Winchester and Floyd 1977). Legend: solid squares, Trousers Lake striped amphibolite; solid circles, Trousers Lake unstriped amphibolite; open circles, Sisson Brook unstriped amphibolite; open circle with cross, Sisson Brook amphibolitic dyke; closed triangles tholeiitic basalts from Tetagouche Group in Bamford Brook area; open triangles, alkalic basalts from Tetagouche Group in Bamford Brook area. A, B, and C are averages from the Tetagouche Group in Bathurst area, see text for explanation. WPA, within-plate alkalic basalts; WPT, within-plate tholeiites; VAB, volcanic arc basalts; MORB, mid-oceanic ridge basalts.

the Trousers Lake suite fall in the mid-oceanic ridge basalt (MORB) or VAB field (Figure 21). Their depletion in Zr, P, and Ti (Figure 20) resembles a volcanic arc pattern but Nb depletion, which is characteristic of many volcanic arc basalts, is absent in the Trousers Lake samples. In summary, the striped amphibolites have a composition similar in most respects to MORB and VAB and the unstriped amphibolites, similar to WPT.

Averages of the tholeiitic, alkalic, and highly alkalic basalt groups recognized by Whitehead and Goodfellow in the Tetagouche Group of the Bathurst area are plotted on Figure 21 as points A, B, and C, respectively. The Trousers Lake striped amphibolites have a major-element chemistry similar to that of the tholeiitic volcanic rocks of the Tetagouche Group (Point A) but contain appreciably less P_2O_5, Ba, Zr, and Ni. The unstriped amphibolite of both the Trousers Lake and Sisson Brook areas possess average trace-element contents greater than the average tholeiitic and less than the average alkalic volcanic rocks of the Tetagouche Group (Figure 20).

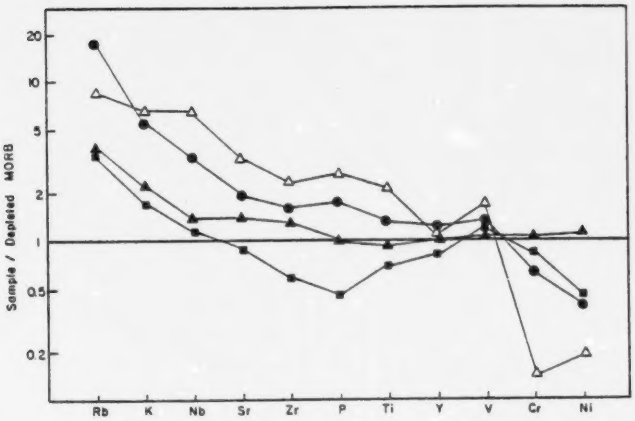

FIGURE 20. Variation diagram for average amphibolites from the Trousers Lake and Sisson Brook suites and average basalts of the Tetagouche Group from the central Miramichi Highlands. Samples are normalized to average "depleted" MORB from the American-Antarctic Ridge (after le Roex _et al_. 1985). Legend: solid squares, average Trousers Lake striped amphibolite (n = 7); solid circles, average Trousers Lake and Sisson Brook unstriped amphibolite (n = 16); solid triangles, average Tetagouche Group tholeiitic basalt (n = 2); open triangles, average Tetagouche Group alkalic basalt (n = 2).

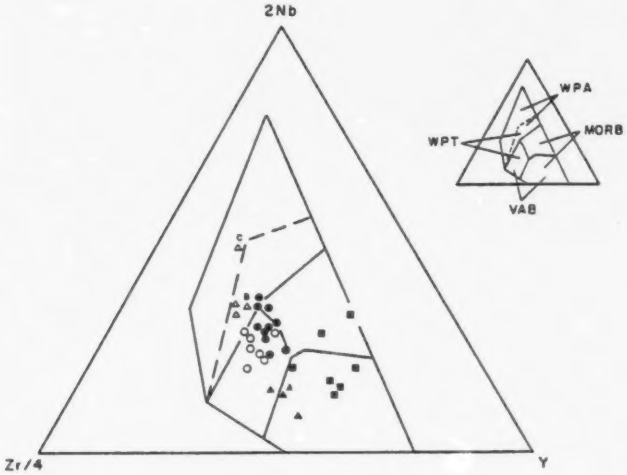

FIGURE 21. Triangular plot of Zr, Nb, and Y (after Meschede 1986). Legend as in Figure 19.

DISCUSSION

It is interesting to note that the Nb-Y-Zr ratios for the unstriped amphibolites form a linear trend between those of the tholeiitic (Point A, Figure 21) and alkalic (Points B and C, Figure 21) basalts of the Bathurst area. This suggests that the unstriped amphibolites may have originated from a mantle source region composed of mixtures of a tholeiitic MORB source and plumes of alkalic basalt (WPA).

The striped variety of the Trousers Lake suite possesses a VAB or MORB composition in marked contrast to the WPT character of the unstriped amphibolites (Figure 21). However, the striped amphibolites do resemble tholeiitic basalts of the Tetagouche Group except for depletion in some trace elements. Trace-element ratios plotted on Figure 21 are more scattered for the striped amphibolites than for the Tetagouche basalts, but this may be due to some mobility of these elements under high-grade metamorphic conditions. The similarities to the Tetagouche Group are increased by the presence of banded iron formation in rubble just to the east of Gulquac Lake. Iron formation is common in the Tetagouche Group and forms the hanging wall to the huge Brunswick Mining and Smelting sulphide orebody near Bathurst. It could be contended, however, that the striped amphibolites are perhaps Cambrian or Precambrian in age if their different elemental composition compared to the Tetagouche tholeiites (Figure 20) is regarded as a primary feature.

The petrochemistry of the amphibolites outlined above is consistent with the recent model of van Staal who interprets the Ordovician volcanic rocks of the Tetagouche Group to have formed in a back-arc environment southeast of the Paleozoic Iapetus Ocean. Using this model, the striped amphibolites in the central Miramichi Highlands would mark a period of eruption coeval with the Middle Ordovician basalts of the Tetagouche Group. This was followed in the later Ordovician by an intrusive episode represented by the unstriped amphibolites and felsic orthogneisses. The differences in chemical composition between the unstriped amphibolites and basalts can be explained by derivation from source regions formed from variable mixtures of MORB-source rock and plume-type basalt.

GOLD-BEARING POTENTIAL OF MAJOR TECTONIC BOUNDARIES IN NEW BRUNSWICK

L.R. Fyffe, Senior Geologist

New Brunswick is divided into several tectonostratigraphic terranes based on the uniqueness of their pre-Silurian stratigraphy. Younger rocks unconformably overlying these terranes are referred to as cover sequences. From northwest to southeast, the following terranes and cover sequences are recognized: Matapedia Cover, Elmtree Terrane, Miramichi Terrane, Fredericton Cover, St. Croix Terrane, Mascarene Terrane, and Avalonian Terrane (Figure 22).

Major faults mark the boundaries of the tectonostratigraphic terranes (numbered on Figures 22 and 23). Some of these faults were apparently buried beneath the cover sequences and subsequently have been reactivated to displace the covering strata. Thus, the Rocky Brook-Millstream Fault, which separates the Elmtree and Miramichi terranes, extends into the Matapedia Cover Sequence; the Fredericton Fault, which may mark the boundary of the Miramichi and St. Croix terranes, transects the Fredericton Cover Sequence. Reactivation on the bounding faults has occurred mainly by dextral transcurrent movement. Faults that mark the boundaries between terranes and cover sequences (i.e., Portage Lake-Serpentine River, Woodstock-Catamaran, Jacquet River, and Bamford Brook faults) may represent splays diverging from these major transcurrent systems.

Recent gold finds in northern New Brunswick appear to be localized along splays of the Rocky Brook-Millstream fault system. For instance, the gold occurrence at Alcida to the northwest of Bathurst is found associated with a gabbroic dyke in a fault zone between the Elmtree Terrane and Silurian rocks of the Matapedia Cover Sequence to the south. Farther west in the Upsalquitch Lake area, several discoveries occur in the vicinity of dioritic dykes that intrude brecciated fault zones within calcareous rocks of the Silurian cover. These breccia zones trend southwestward off the main east-trending Rocky Brook-Millstream Fault. Similarly gold occurrences at Cape Spencer are localized along the Fundy fault system that presumably represents a major tectonic boundary between the Avalonian Terrane of southern New Brunswick and the Meguma Terrane of Nova Scotia.

If the above interpretation is correct, it is evident that many of the major fault zones in New Brunswick have a high potential to be gold bearing. To date, the search for gold has been concentrated only on two of these zones so that much ground remains open for exploration in other areas.

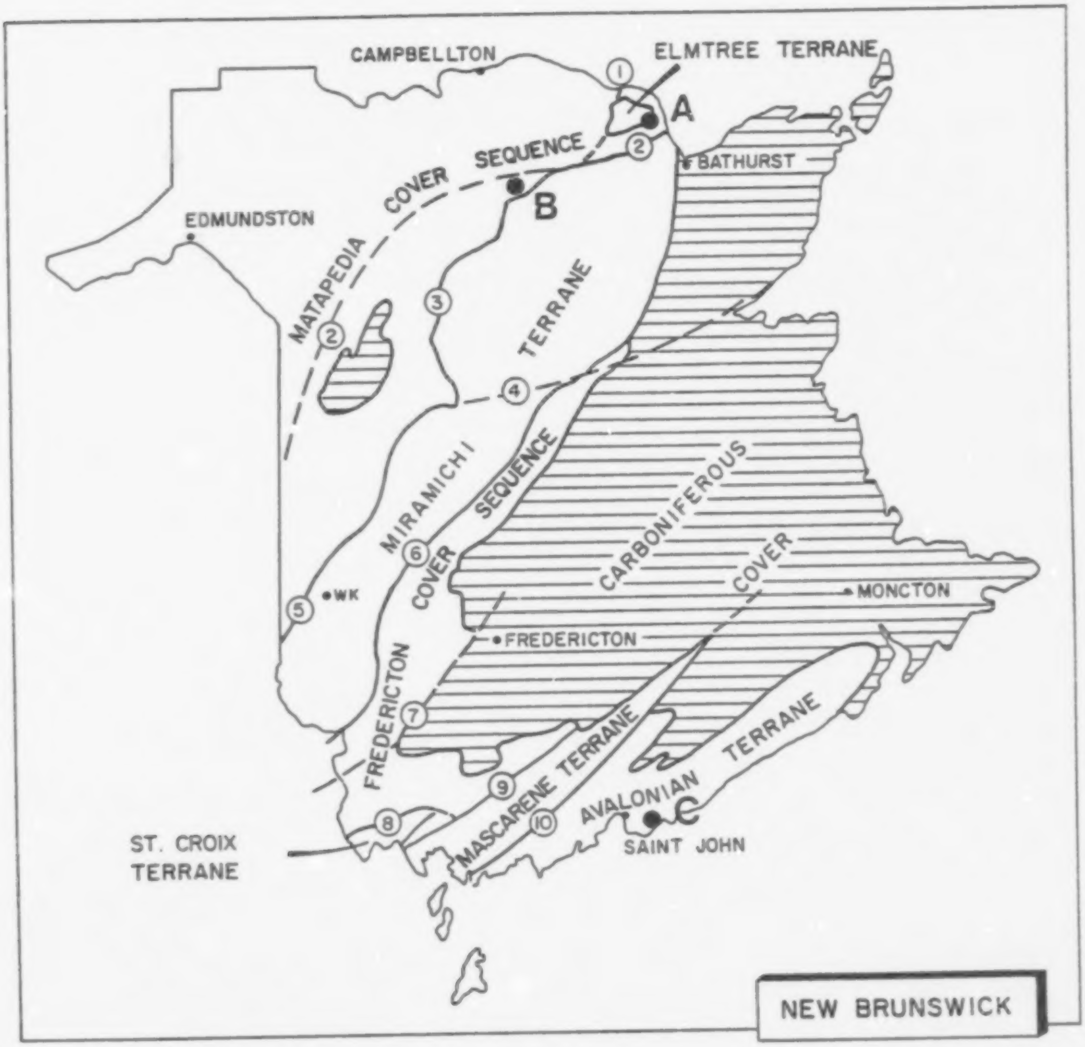

FIGURE 22. Tectonostratigraphic terranes and cover sequences of New Brunswick. 1 = Jacquet River Fault; 2 = Rocky Brook-Millstream Fault; 3 = Portage Lakes-Serpentine River Fault; 4 = Catamaran Fault; 5 = Woodstock Fault; 6 = Bamford Brook-Hainesville Fault; 7 = Fredericton Fault; 8 = Honeydale Fault; 9 = Pendar Brook Fault; 10 = Belleisle Fault. Dashed lines represent faults within the cover sequences. The abbreviation WK = Woodstock. Stars indicate location of recent gold finds. A - Alcida, B - Upsalquitch Lake, C - Cape Spencer.

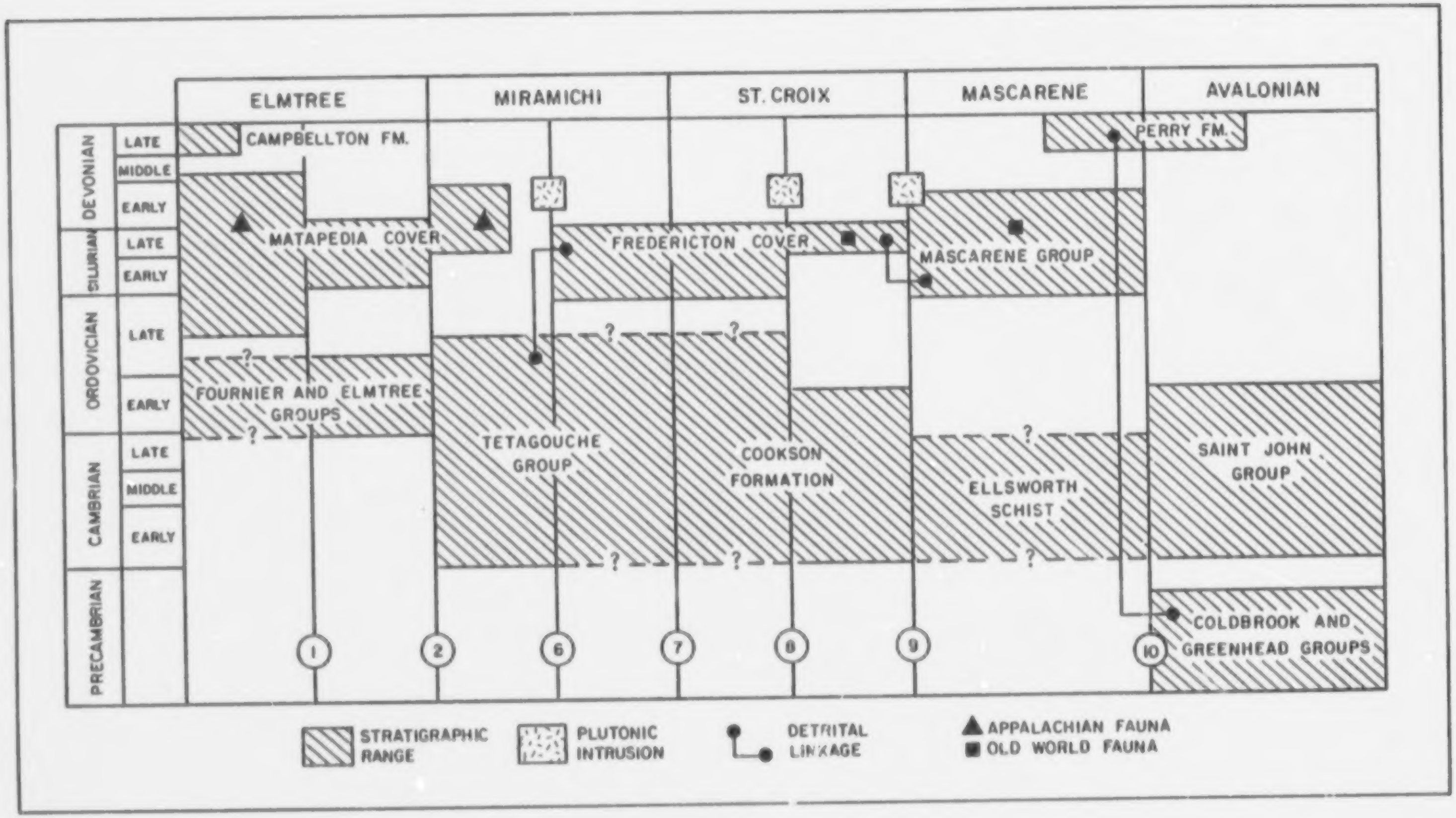

FIGURE 23. Stratigraphic, detrital, and plutonic linkages across terrane boundaries in New Brunswick. Numbers refer to faults listed in Figure 22. Stratigraphic columns represent a composite section drawn between Campbellton and Bathurst in the north and Woodstock and Saint John in the south.

DRILL-CORE MANAGEMENT

G.W. Crouse, Core Librarian

Approximately 20 000 metres of core has been donated to the Province by mining companies this year. This includes core salvaged from the Key Anacon property when the core building was destroyed by vandals. Unfortunately, approximately 80% of the core at Key Anacon was unsalvageable. Area is being cleared at the Madran core repository to accommodate the construction of buildings to house approximately 60 000 metres of core. The computerized data base of the drill core stored by the NBDNRE is being updated.

GEOCHEMISTRY LABORATORY

Valeria Rinco, Geochemical Analyst

Analyses were performed on 531 till samples collected by Toon Pronk in 1986 (NTS 21 O/10). Eight elements (Cu, Pb, Zn, Mn, Fe, Co, Ni and Ag) were analysed by atomic absorption, and two elements (Sb and Mo) by colorimetry. A further 257 samples that were returned us after analyses by Chemex Labs Ltd. of Vancouver for Au, Sb, Ba and As were later analysed for the above-mentioned eight (8) elements.

One hundred and seventy-five samples collected by Paul Chiswell (NTS 21 G/2) were analysed for five (5) elements (Cu, Pb, Zn, Co, and Ag) by atomic absorption, and two (2) elements (Sb and W) by colorimetry.

A total of 1569 samples were analysed by Chemex Labs Ltd. for Au, As, Sb, and Ba. These samples were taken from:

Charlo (NTS 21 O/16) in 1973
Kedgwick (NTS 21 O/11W) in 1980
Upsalquitch Forks (NTS 21 O/10) in 1980
Tetagouche Lakes, west half (NTS 21 O/9W) in 1980
Nepisiguit Lakes (NTS 21 O/7) in 1976 and 1979

Results were released in the spring of 1987. Another 570 samples were analysed for Au, As, Sb, and Ba from Riley Brook (NTS 21 O/3) in 1982. Results were released in October, 1987.

PUBLICATIONS 1987 - GEOSCIENTIFIC SERVICES SECTION

FYFFE, L.R. 1987. Petrochemistry of amphibolites from the Miramichi Highlands, New Brunswick (abstract). Atlantic Geoscience Symposium, Fredericton 1987, Maritime Sediments and Atlantic Geology, p. 98.

FYFFE, L.R. and BARR, S.M. 1986. Petrochemistry and tectonic significance of Carboniferous volcanic rocks in New Brunswick. Canadian Journal of Earth Sciences, 23, pp. 1243-1256.

GARDINER, W.W. 1986. Geology of Little Dungarvon River and Four Mile Brook showings, central New Brunswick (part of 21 J/10E). Scale: 1:10 000 (Canada-New Brunswick Mineral Development Agreement (1984-1989) Project). New Brunswick Department of Natural Resources and Energy, Mineral and Energy Division. Plate 87-56.

_________ 1986. Geology of Trout Lake showings, central New Brunswick (part of 21 J/10E). Scale: 1:10 000 (Canada-New Brunswick Mineral Development Agreement (1984-1989) Project). New Brunswick Department of Natural Resources and Energy, Mineral and Energy Division. Plate 87-58.

GARDINER, W.W. and GARNETT, K. 1986. Geology of the Trout Lake and Rocky Brook granites (parts of 21 J/10). Scale: 1:20 000 (Canada-New Brunswick Mineral Development Agreement (1984-1989) Project). New Brunswick Department of Natural Resources and Energy, Mineral and Energy Division. Plate 87-57.

_________ 1986. Geology of the Dungarvon and Sisters Brook granites (parts of 21 J/10 and J/15). Scale: 1:20 000 (Canada-New Brunswick Mineral Development Agreement (1984-1989) Project). New Brunswick Department of Natural Resources and Energy, Mineral and Energy Division. Plate 87-55.

MacLELLAN, H.E. 1986. Geology of the Burnthill Granite (21 J/10). New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 86-241.

MacLELLAN, H.E. and TAYLOR, R.P. 1987. Petrogenetic studies of the Burnthill Granite and related Sn-W mineral deposits, central New Brunswick (abstract). Atlantic Geoscience Symposium, Fredericton 1987, Maritime Sediments and Atlantic Geology, pp. 103-104.

PICKERILL, R.K., FYFFE, L.R., and FORBES, W.H. 1987. Late Ordovician-Early Silurian trace fossils from the Matapedia Group, Tobique River, western New Brunswick, Canada. Maritime Sediments and Atlantic Geology, 23, pp. 77-93.

PRONK, A.G. 1987. Till geochemistry and exploration for gold in northern New Brunswick (abstract). Atlantic Geoscience Symposium, Fredericton 1987, Maritime Sediments and Atlantic Geology, 23, p. 105.

________ 1987. Glacial geology of northern New Brunswick and its application to gold exploration (abstract), XII INQUA Congress, Ottawa 1987, program with abstracts, p. 246.

________ 1987. Glacial deposits of northern New Brunswick and their relation to forest productivity (abstract), XII INQUA Congress, Ottawa 1987, program with abstracts, p. 246.

________ 1987. Surficial geology and till geochemistry of the Upsalquitch Forks (21 O/10) map area (with emphasis on gold distribution in tills). Department of Natural Resources and Energy, Minerals and Energy Division, Geological Notes Series P.M. 87-47, p. 8, 4 maps.

________ 1987. Pleistocene glacial dispersal and history in Buttle Valley, Vancouver Island, British Columbia: a feasibility study for alpine drift prospecting: Discussion. Canadian Journal of Earth Sciences, 24, pp. 1504-1505.

WILSON, R.A. and SULLIVAN, R. 1987. Geology of the New Denmark area (parts of 21 J/13,14 and 21 O/3,4). Scale: 1:20 000. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 87-8.

GEOLOGICAL SURVEYS BRANCH

GEOSCIENTIFIC DATA SECTION

GEOSCIENTIFIC DATA SECTION - 1987 ACTIVITIES

D.J.J. Carroll, Coordinator

The Geoscientific Data Section of the Geological Surveys Branch is responsible for providing a variety of geoscientific, technical, and support services to the staff of the Minerals and Energy Division. In addition, the staff of the Geoscientific Data Section provide assistance to the public and mineral exploration industry, in particular, by supplying hardcopy publication material on the geology and mineral resources of the province.

The Geoscientific Data Section is made up of three units; the Geoscientific Editorial Services, Geoscientific Cartographic Services, and Geoscientific Information Services units (Figure 24).

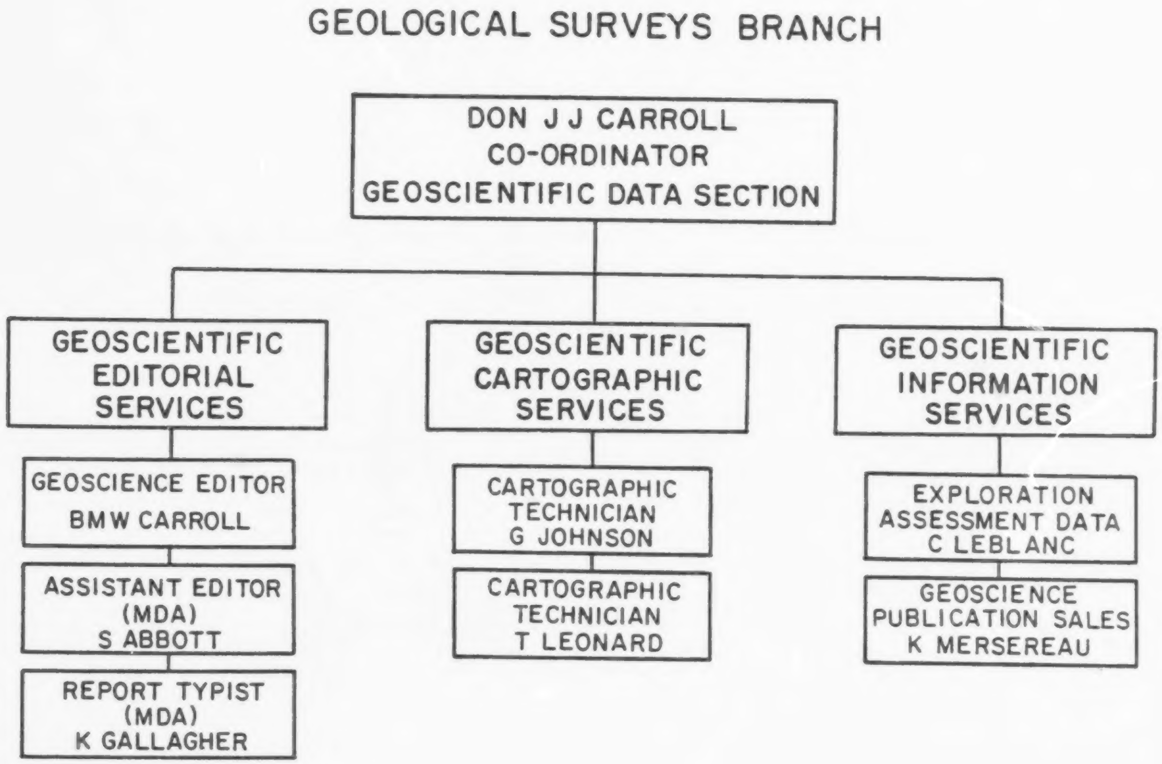
GEOLOGICAL SURVEYS BRANCH
DON J J CARROLL
CO-ORDINATOR
GEOSCIENTIFIC DATA SECTION
GEOSCIENTIFIC EDITORIAL SERVICES
GEOSCIENCE EDITOR
BMW CARROLL
ASSISTANT EDITOR (MDA)
S ABBOTT
REPORT TYPIST (MDA)
K GALLAGHER
GEOSCIENTIFIC CARTOGRAPHIC SERVICES
CARTOGRAPHIC TECHNICIAN
G JOHNSON
CARTOGRAPHIC TECHNICIAN
T LEONARD
GEOSCIENTIFIC INFORMATION SERVICES
EXPLORATION ASSESSMENT DATA
C LEBLANC
GEOSCIENCE PUBLICATION SALES
K MERSEREAU

FIGURE 24. Organization chart for Geoscientific Data Section.

The total provincial budget for the Section in 1987 is $231 300.00 of which 29% is operating cost. Under the Canada-New Brunswick MDA (1984-89), the Geoscientific Data Section is responsible for Public Awareness, Information, and the Administration portion of the Agreement. Funding associated with this program is $298 000.00.

A brief synopsis of activities carried out in 1987 by the Geoscientific Data Section is described below. In addition to the work that is normally part of the provincial program, the following descriptions will include information on Public Awareness projects carried out under the Canada-New Brunswick MDA (1984-89) by the federal government; Energy, Mines and Resources Canada, Communications Branch.

GEOSCIENCE EDITORIAL SERVICES

The responsibilities of this unit are to edit all geoscientific reports and maps that are produced by or for the Minerals and Energy Division. In 1987, the staff of this unit have edited and/or prepared for publication 23 reports and 101 maps. The following is a list of these reports:

GENERAL DEVELOPMENT AGREEMENT

KEYS, D. and HENDERSON, R.E. 1987. An inventory of the peat resources of New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 83-10.

LUTES, G.G. 1987. Geology and geochemistry of the Pokiok Batholith, New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Report of Investigation 22, 54 p., 2 maps.

McCUTCHEON, S.R. and RUITENBERG, A.A. 1987. Geology and mineral deposits of the Annidale-Nerepis area, New Brunswick. New Brunswick Department of Natural Resources and Energy, Mineral Resources Division, Memoir 2, 152 p., 4 maps, cross section.

McLEOD, M.J. 1987. Geology, geochemistry, and mineral deposits of the Big Salmon River - Goose River area, New Brunswick, map area S-27 and parts of R-27, S-26, and T-26 (parts of 21 H/6 and 21 H/11). New Brunswick Department of Natural Resources and Energy, Mineral Resources Division, Report of Investigation 21, 47 p., 9 maps.

PROVINCIAL

ABBOTT, Shasta A. 1987. Twelfth Annual Review of Activities, Project Résumés, 1987. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Information Circular 87-2.

BRINSMEAD, R.A. and SEAMAN, A.A. 1987. Granular aggregate resources, Petitcodiac (NTS 21 H/14) map area, New Brunswick, New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 87-1.

CARROLL, Barbara M.W. 1987. New Brunswick's Mineral Industry, 1986. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Information Circular 87-1.

HASSAN, H.H. and HALE, W.E. (UNB Geology Department). 1987. Uranium and thorium in rocks of southwestern New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 86-10.

ST. PETER, C. 1987. Catalogue of well data for boreholes in southern and eastern New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 87-15, 338 p.

TAGGART, J.L.C., CHANDRA, J.J., and LEGER, J.V. 1986. A report on the New Brunswick Mining Industry: occupational and economic outlook to 1995. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 86-13.

TAGGART, J.L.C., CHANDRA, J.J., and LEGER, J.V. 1986. Rapport sur l'industrie minière au Nouveau-Brunswick: Emploi et economie perspectives jus qu'en 1995. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Dossier Public 86-14 (french version of OF 86-13).

MINERAL DEVELOPMENT AGREEMENT

ARSENEAU, André and DAIGLE, Jean-Yves 1987. Etude sur l'usage de la tourbe dans l'argiculture (Survey of the users of peat in agriculture). New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Dossier Public 87-8.

BARTLETT, D.R., WITTECK DEVELOPMENT INC. 1987. Process evaluation of selected options for treating New Brunswick manganese mineral deposits. Volume II - economic analysis (Project 5211). New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 87-13 (Fed. M.D.A.)

DAVIS, Dallas W. 1987. The limestone industry in New Brunswick, Volume I - Report. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 87-6, 117 p.

DAVIS, Dallas W. 1987. The limestone industry in New Brunswick, Volume II - Appendices. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 87-7, 168 p.

DAY & ASSOCIATES, LEE FOX SERVICES LTD., and THE COOPERS & LYBRAND CONSULTING GROUP. 1987. Study of the non-metallurgical markets for manganese ore. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 87-9.

LeBLANC, P., BAND, W., and CHAPMAN, J. 1987. Peat Moss Market Study. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division. Open File Report 87-16.

LeBLANC, P., BAND, W., and CHAPMAN, J. 1987. Etude des marchés de la tourbe horticole. (French version of OF 87-16). New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division. Open File Report 87-17 (Dossier Public).

McGRATH, James J. 1987. Custom mill options for New Brunswick complex sulphide ores. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 87-11, 48 p.

NEWMAN, D. and BARTLETT, D.R., WITTECK DEVELOPMENT INC. 1987. Process evaluation of selected options for treating New Brunswick manganese mineral deposits, Volume I - results of testwork (Project 5211). New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 87-12 (Fed. M.D.A.)

PRONK, A.G. 1987. Surficial geology of Upsalquitch Forks area (21 O/10). New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Geological Notes Series P.M. 87-47 (Map Plate 87-47A, B, C, D; Scale: 1:50 000).

THE PDA GROUP INC. in association with JACQUES WHITFORD & ASSOC. LTD. 1987. Final report - market analysis for New Brunswick, Nova Scotia and Newfoundland - dimension stone. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 87-10, 114 p.

MINERAL EXPLORATION ASSESSMENT REPORTS

Since the beginning of the calendar year, the Mineral Lands Section of the Mineral Development Branch has received from the mineral exploration industry 69 assessment reports. These reports consist of 32 public files and 37 reports that are to be held with a confidential status for a maximum period of two years. The majority of these reports have been indexed and included in the Geological Survey of Canada's bibliographic data base called **GEOSCAN**. A GEOSCAN index to the 1986-87 assessment reports will be produced for distribution at the this year's Annual Review of Activities.

The Geoscientific Data Section is continuing to microfilm all incoming assessment reports that are publically available at this time. Duplicate microfiche copies are placed in our two regional offices in Bathurst and Sussex as well as selected public libraries across the province.

GEOSCIENTIFIC PUBLICATIONS

The Geoscientific Information Services unit of the Geoscientific Data Section plays an important role in the dissemination of geoscientific data to the mineral exploration industry in particular, but also to engineering and consultants not to mention the general public. Since the beginning of 1987, 19 reports and 134 maps have been added to our Supplementary List of Publications. For the period January-September 1987, publications sales from the Fredericton office totalled approximately $22 557.09. The total number of specific requests for information during this same period was over 875, resulting in the distribution of 4787 documents.

In order to inform the users of geoscientific data of any new publications that are produced either by or for the Minerals and Energy Division including those of the Geological Survey of Canada, funded under the Canada-New Brunswick Mineral Development Agreement (1984-89), the Geoscientific Data Section maintains a publication notification list. In 1987, this Section was involved in the preparation of nine publication releases. These releases were as follows:

1. DNRE April 14/87	Gold in Tills, Tetagouche Lakes Map Area (21 O/9)
2. DNRE May 15/87	Memoir 2, Report of Investigation 19, Open File Reports 87-6, 7, 8, 9, 10
3. GSC May 26/87	Airborne Gradiometer Surveys, Bathurst area (21 J/13, 14, 15; 21 O/2, 3)
4. GSC June 24/87	Regional Stream Sediment and Water Geochemistry Rconnaissance Survey, Southern New Brunswick. (21 G/1, 8; 21 H/4, 5, 6, 10, 11, 12, 14, 15)

5.	DNRE August 4/87	Re-analyses of Stream Sediment Samples (21 O/7, 9, 10, 11, 16)
6.	GSC September 24/87	Airborne Gamma-Ray Spectrometer Survey, Holmes Lake area (21 J/15, 21 O/2)
7.	DNRE October 20/87	Till geochemistry and surficial geology of the Mascarene Peninsula and southern Deer Island areas (21 G/2c, 2d; 21 B/14h, 15e)
8a.	GSC October 27/87	Airborne Gama-Ray Spectrometer Survey, Northern New Brunswick. 21 O/9, 10, 15, 16; 21 P/5W, 12W, 13W
8b.	DNRE October 27/87	Stream Sediment Geochemistry Riley Brook Area (NTS 21 O/3)
9.	DNRE November 19/87	Lithogeochemistry and Metallic Mineral Potential of Volcanic rocks along the Jacquet River Fault, northeastern New Brunswick. Open File Report 87-18.

PUBLIC AWARENESS ACTIVITIES

During 1987, the Geoscientific Data Section was extensively involved in activities aimed at increasing the general public's awareness of New Brunswick's rich and diversified mineral resources. In addition, the continuance of activities that publicize the work being done under the Canada-New Brunswick MDA (1984-89) was another task carried out by this Section. A summary of these various activities follows.

DISPLAYS:

Three major displays associated with public awareness activities were completed in 1987. The first display, produced by the Geological Surveys Branch, was exhibited at the Annual General Meeting of the Prospectors and Developers Association in Toronto. It was part of the Provincial Geologists geoscience exhibit forum whose objectives are to publicize the various activities carried out by or for the participating provinces and territories. New Brunswick's exhibit theme concentrated on gold activities in the province, but also highlighted the work done by H.E. MacLellan on the granites in the Burnthill area. Ms. MacLellan was also our provincial speaker at this year's PDA.

The second display, aimed at the general public, publicizes the potash resources of New Brunswick. This display - researched, designed, and produced by G. Martin (Language Unlimited) and M. Butler (Butler Design and Graphics) with cooperation and assistance from both the Potash Company of America (PCA) and Denison-Potacan Potash Company - was completed in late July. It was designed to complement the existing eight-panel display (which concentrates on the metallic and fossil fuel mineral resources of New Brunswick that was produced under the previous General Development Agreement). It will be available to the public on a loan basis. The potash display was borrowed by PCA for use at the Sussex Fall Fair in September.

The Minerals and Energy Division loaned the New Brunswick Mining and Mineral Interpretation Centre at Petit Rocher the previously mentioned eight-panel display. In addition, the Division agreed to commission the design and production of a separate display to be located permanently at the Centre. This unit, funded under the Canada-New Brunswick MDA (1984-89), was produced in-house. The display consists of a facsimile Geological Highways Map of New Brunswick and has four inserts representing four areas of geological interest. Each insert has a triple-revolving electrical unit that displays a detailed location map and a colour photograph for a specific geological feature in those areas.

EDUCATION PROJECT:

The Minerals and Energy Division considered a project proposal from G. Martin to undertake a project intended to increase the knowledge of junior high school students with respect to rocks, minerals, and our provincial mineral resources.

After details were worked out with the Department of Education, a preliminary questionnaire was sent out to junior high schools in the province to gauge the response to such a project, and the resultant positive feedback convinced the Division to go ahead with the project.

The pilot program, called "On The Rocks", was funded under the Canada-New Brunswick MDA (1984-89), and was based on a 55-minute oral presentation by G. Martin tc over 350 classes, representing 71 schools and approximately 11 000 students. Follow-up evaluation confirmed that this type of project was well received, and beneficial to students and teachers alike. It is useful because of the lack of qualified personnel in the school system to speak on these specialized subjects.

The "On The Rocks" pilot project tour became so well known that additional lectures were given. Because of the numerous requests, the Department of Education provided the additional funds.

NEW BRUNSWICK MUSEUM:

The Natural Science Division of the New Brunswick Museum in Saint John has one of the largest collections of rocks, minerals, and fossils in New Brunswick. These items are of great historical value because they have been collected by some of our Province's most noted geoscientists. This collection has not been catalogued and deposited in proper storage units due to the lack of sufficient quantities of proper facilities. The New Brunswick Museum has recently established a position of Assistant Curator, Natural Sciences. One of the major tasks undertaken by this individual, Dr. R. Miller, has been to start cataloguing this important collection.

In order to properly store this collection, the New Brunswick Museum has asked and received funding from Energy, Mines and Resources Canada under the Canada-New Brunswick MDA (1984-89) to purchase special storage cabinets.

AUDIO/VISUAL PRODUCTIONS:

One of the highlights of 1987 has been the completion of the first of four Atlantic Geoscience Society's video productions. The first video, called "The Mineral Wealth of Atlantic Canada" was completed earlier this year and was completely funded by Energy, Mines and Resources Canada under the Canada-New Brunswick and Canada-Nova Scotia Mineral Development Agreements. Copies of this video have already been distributed by Energy, Mines and Resources Canada to some schools across the Maritimes. The second video, "The Appalachian Story" is nearing completion and will be funded either by private or public donations. The target audiences for these AGS-sponsored programs are the junior and senior high schools and the general public.

Each year, the Geoscientific Data Section receives requests from school teachers for information on mineral resources and geoscience-related topics in audiovisual format or print. Gradually, the Section is building up a collection of videos, films, and slide programs for loan to various interest groups. Some of the titles that are available from the Geoscientific Data Section include:

1. "The Awakening Giant"
2. "Sensible Sequence"
3. "Coastline Conservation"
4. "The Beach - A River of Sand"
5. "Mineral Industries of New Brunswick"
6. "New Brunswick's Peat Resources"
7. "Carboniferous Drilling Project"
8. "Taming a Hazardous Waste with Lime"
9. "Lime - The Versatile Chemical"
10. "The Mineral Wealth of Atlantic Canada"
11. Peat Research Centre - Shippagan

PUBLICATIONS:

A coloured pamphlet entitled "Peat Research and Development Centre" was produced to complement the recently released audiovisual slide program about New Brunswick's peat industry and the work that is being carried on at the Shippagan research centre. It was completed this fiscal year and was produced and funded by Energy, Mines and Resources Canada under the Canada-New Brunswick MDA (1984-89).

MINERAL DEVELOPMENT BRANCH

PROCESS STUDIES GROUP - 1987 MDA ACTIVITIES

D. Thibault, Process Chemical Engineer

The overall goal of the Process Studies Group is to evaluate emerging technologies and processes, to liaise with industry and to recommend to the Province various ways in which research and development can be of assistance to the mineral industry of New Brunswick. Various projects carried out under the Mineral Processing Investigations Program (MPIP) have led to further development by industry under the Mineral Investment Stimulation Program (MISP). As a result of the studies being carried out by both programs, various concepts have been identified for the development of New Brunswick mineral resources, which provide some basis for a centralized theme for an industrial development strategy. The following concepts have been recognized as areas which will diversify the mineral industry (as a mandate for the MDA) and will be studied by the Process Studies Group for the Fiscal Year 87-88.

A. High-growth metals such as titanium, zirconium, gallium, and rare earths have been identified as metals where North American sources are highly dependent on imported ores or concentrates. A North American source of these metals is of great interest to most refining operations where refineries have a mandate to procure the cheapest raw material source. The potential for New Brunswick to produce concentrates of these high-growth metals is to be reviewed. A flowsheet for the production of magnesium compounds from dolomite ores will also be reviewed.

B. The price of tungsten and the oversupply of concentrates have resulted in the closure of Mt. Pleasant Tungsten Mine. In the event of a strengthening tungsten market, a lower manufacturing cost will be required for New Brunswick to remain competitive. Processing limitations and low-cost processing alternatives are to be identified for the North Fire Tower Zone of Mt. Pleasant.

C. Various refractory gold ores (limited extraction of gold, by leaching) have been identified from previous studies done on the leachability of gold from various ores of New Brunswick. Development of these ores has been limited because of high-cost extraction methods and environmental problems associated with arsenic. A study is to be carried out on the various technologies to overcome these problems, which will be used to characterize provincial ores.

D. A major drawback to previous metal extraction in New Brunswick is the control of cyanide levels in the processing effluents. A review of cyanide-removal technology will be carried out to identify a direction for further development.

E. Bulk-sulphide flotation has been identified as a major area for development in the upgrading of complex sulphide ores with respect to add-on processing methods for refining concentrates and to improving recoveries of conventional selective flotation circuits. Lab and in-plant studies will be carried out to characterize various sulphide deposits of New Brunswick and to identify the commercial potential of new technologies for bulk-sulphide concentration.

F. Flash flotation and column flotation are fairly new technologies to overcome loss of material by over-grinding and are used to improve on grade of industrial-mineral and metallic-mineral concentrates. These flotation concepts are to be reviewed to identify the commercial potential of improving production efficiencies.

6. Chloride hydrometallurgy has been identified from previous studies as a possible technology to produce antimony products from antimony sulphide concentrates. Further investigations will be carried out on this technology to identify the economic potential of a commercially producing antimony oxide and/or antimony products.

MINERAL PROCESSING INVESTIGATIONS PROGRAM (MPIP) - MDA

Dean Thibault, Process Chemical Engineer

The Mineral Processing Investigations Program is being administered by the provincial government and is fully funded by Federal government under the Canada-New Brunswick MDA. Investigations are to be carried out using bench scale testing methods to techniques of improving grade-recovery relationships and to identify alternative processing methods. The objective of the program is to generate technical information on metallurgical processing and refining of concentrates, hence to establish a development strategy for various provincial ores.

The overall program has been aimed at the diversification of the mineral industry in New Brunswick. From a review of the provincial resource base, it has been found that a fair number of diversified mineral resources has been identified with complete mineralogy and limited background on mineral separation and/or extractability characteristics. It is therefore our interest to identify possibilities for mineral processing alternatives and recognize limitations to development within New Brunswick. The administration of an "incubation lab" was established under the MPIP so that concepts of milling and metal extraction undergo a technical and economic evaluation for commercialization, hence identify the need for large-scale research and development.

Projects being administered under the MPIP by the Process Studies Group originate through discussion with industry and other government departments. The following projects are at various stages of completion where project findings have resulted in spin-off research and development by government and private-sector funding.

A. Optimization of Grade and Recovery at Durham Antimony Mine

In-plant sampling was done on all streams of the Durham concentrator using various flowsheet configurations. The loss of antimony was quantified by a mass balance program and by determination of mineral types and liberation size data. Results of mass balance calculations and mineralogy indicate that optimum grade and recovery can be achieved between 25 and 75 microns where major loss of antimony can be attributed to unliberated stibnite.

B. Further Processing of Antimony Concentrates

A literature review was carried out on the developments in pyrometallurgical and hydrometallurgical processing methods to treat antimony sulphide concentrates and to produce a marketable grade antimony oxide and/or antimony metal. Various processing alternatives were bench tested for technical and economic assessment. A low-temperature chloride leach processing flowsheet has been identified as a concept for producing marketable oxide.

C. Leachability of New Brunswick Gold Ores

Rolls tests were done on various gold ores using cyanide as an extractant. A majority of the ores tested have an extractability of 80-90% Au with cyanide consumptions of 3-4 kg NaCN per tonne ore (head grades averaging 0.78-1.78 g/t Au). Simulated heap-leach testing in 6" columns illustrated that perculation leach methods were successful in extracting the gold from 3/8" crushed low-grade ores. Various refractory ores were identified (not readily amenable to cyanidation) due to the fine-grained nature of gold associated with arsenopyrite. Beneficiation of refractory ores was quite successful with PAX/MIBC flotation, upgrading 5.7 g/t Au ore to 16.3 g/t with 91% recovery. Further research is required on alternative chemical methods of processing refractory ores.

D. Extraction possibilities of High-Growth Metals

A market review was carried out to identify several metals that have high-growth potential. From the results of the market review, various ores and processing streams of all concentrators were tested for titanium, zirconium, germanium, gallium, and rare earths. Of the various ores identified as containing economic levels of these metals, beneficiation was found to be non-selective in upgrading. Chemical processing methods are now being reviewed to establish concepts for further development.

E. Benefication of Complex Sulphides for Add-On Processing Methods

A literature review of research and development carried out to date on beneficiation alternatives of complex sulphides, has indicated that a bulk-sulphide flotation is the most attractive alternative for add-on chemical processing methods and that further development is required on flowsheet design. Concepts for flowsheet alternatives are being identified where bench scale characterization of flowsheets will be carried out on various sulphide ores. The technology of column flotation is also being reviewed to identify the potential of achieving a selective bulk flotation.

F. Flowsheet Development of Mt. Pleasant Tungsten Ores

Preliminary economic assessment of the North Fire Tower Zone has indicated that revenue may be obtained from flourite, rare earths, and possibly base -etal sulphides in addition to tungsten. Tungsten being the major revenue generator of the ore at today's metal prices, has encouraged the development of low-cost beneficiation methods for wolframite as a primary flowsheet. Initial testing on the development of a gravity separation circuit has indicated that the optimum liberation of wolframite is approximately 75 micron and that gravity separation can achieve a 20% WO_3 concentrate from 0.35% WO_3 at 75-80% recovery. The concept of a leach-solvent extraction-hydrolysis circuit is now being reviewed to produce ammonium para-tungstate (APT) from gravity concentrates.

MINERAL INVESTMENT STIMULATION PROGRAM (MISP)

Robert Harris, MDA Project Engineer

The MISP is a program under the current MDA which is designed to promote the development of the mineral sector of the Province by providing financial assistance to the mineral/mining industry. The assistance is to help companies/individuals undertake projects aimed at fostering development in specific areas such as further characterization of established deposits, mineral (primary) processing and marketing. To date, there are thirteen projects funded under the program, which reflect a total financial assistance of about $436 368. Below is a summary of each of the approved projects:

	Project Title	Responsibility	Level of Funding (% of Project Cost)
1.	"Antimony Float Study"	Durham Resources Inc.	12 743 (50%)

Project investigated the problems explaining the consistently low (85%) recovery of antimony at the plant's concentrator. The work entailed bench flotation tests under varying reagent concentration and type, size analysis on feed stock, and product streams to determine metal (antimony) distribution and microscopic work to evaluate the characteristics of flotable and non-flotable antimony-bearing minerals.

2.	"Antimony Smelting Study"	Durham Resources Inc.	5 450 (50%)

Project consisted of a series of smelting tests for the purpose of assessing the feasibility of producing antimony metal from a sulphide concentrate. Various fluxes and reductants were tested.

3.	"Mineral Liberation Investigation"	Brunswick Mining and Smelting (BMS)	50 000 (42%)

Project encompassed a comprehensive mineralogical survey with the objective of determining the distribution of free and unliberated mineral grains within BMS' concentrator. Tests included grain-size analysis and mineral chemistry determinations of samples taken at various stages in the processing circuit.

4. "Metal Distribution Study" Brunswick Mining 30 000 (50%)

Project is aimed at determining the distribution of metals and trace elements within the concentrator at BMS. The work will require the collection, size analysis, and chemical analysis of various samples taken from the grinding, classification, and flotation circuits of the concentrator.

5. "Pyrite Flotation Tests" Brunswick Mining 16 850 (50%)

Project investigated the technical feasibility of producing a marketable pyrite concentrate on a pilot scale. The work consisted of pyrite classification and flotation experiments.

6. "Pressure Filtration Evaluation Brunswick Mining 20 725 (50%)

Project evaluated the effectiveness of a verti-press pressure filter on the dewatering of base-metal concentrates. The work operated on a pilot scale and utilized feedstock composed of a lead concentrate. The parameters considered were production rate, air consumption, product moisture, and cycle time.

7. "Flash Flotation Study" Durham Resources Inc. 16 600 (50%)

Project studied the effectiveness of flash flotation on the recovery of antimony minerals (mainly stibnite) and on the reduction of slime loss due to overgrinding of ore. The flash cell was installed in the grinding circuit as a method to recover coarse liberated antimony minerals.

8. "Purification of Zinc Concentrates" Brunswick Mining 34 000 (50%)

Project will assess the causes of zinc concentrate contamination and will evaluate the potential for improvement by column flotation. Activities will include column flotation experiments and mineralogical examinations of the process streams.

9. "Further Characterization of Cape Spencer Gold Deposit Mispec Resources Inc. 50 000 (49%)

Project proposes to expand an established reserve of gold-bearing ore at Cape Spencer by diamond-core drilling, trenching, and assay analysis of the resulting samples for gold. The primary objectives are to further define and expand the gold zone known as the "Road Zone" and to ascertain the grade of the enriched surficial expression of the same zone.

10. "Further characterization of Plymouth Mn Deposit" Maritime Resource Inc. 50 000 (47.6%)

Project will entail the further characterization of the established Plymouth Mn deposit near Woodstock, N.B. by trenching and diamond-core drilling at selected sites and by detailed analysis of the resulting core samples for determining the content of Mn and other interesting minerals.

11. "Gold Assessment at Lake George" Dominion Explorers 50 000 (41%)

Project will assess the magnitude of a gold showing at the 850' level of the existing antimony mine at Lake George. The proposed work includes 500' of drifting with sampling at various intervals in effort to determine the width and length of auriferous sulphides in the fractured zones separate and north of the main antimony vein.

12. "Reserves Extension of Antimony-Part 1" Dominion Explorers 50 000 (27%)

Project will try to prove up additional adjoining reserves for the already producing antimony mine at Lake George by diamond-drill testing for quartz/antimony veins that may exist in the untested area south of the main east-west producing vein. It is planned that 11 000' of diamond drilling will be done along a 12-mile picket line grid. The resulting core samples will be analysed for antimony content.

13. "Reserves Extension of Antimony-Part 2" Dominion Explorers 50 000 (25%)

Project will try to prove up additional adjoining reserves for the already producing antimony mine at Lake George by diamond-drill testing of various structures in the area of the Lawrence vein (discovered in the 1920's) approximately 4000' west of the main shaft. This investigation will also test some north-south-trending geochemical anomalies. It is planned that 12 000' of drilling will be done along a 13-mile picket line grid. The resulting core samples will be analysed for antimony content.

MINE ENGINEERING

S. McEwan, Mining Engineer

The Mineral Development Branch of the NBDNRE has two specific areas of responsibility with regard to N.B.'s mineral resource. The first of these concerns is the administration of the Mining Act to ensure the proper exploitation of the resource, for the full benefit of the people of N.B. The second aspect the Branch is involved with is that of promoting and developing N.B.'s mineral resource. The Mine Engineering section of the Branch is directly involved in fulfilling both of these responsibilities.

With regard to the administration of the Mining Act, Mine Engineering finds itself involved with the following:

1. The monitoring of existing mining operations through the review of mining plans, site inspections, and statistical analysis of production, labour, and capital expenditures. This is an ongoing process to guarantee that the N.B. government is kept fully aware of the state of well-being of the mining industry within the province.

2. The analysis and review of any new mining projects proposed within the province. These projects are reviewed through examination of feasibility studies, reclamation and waste management plans submitted by the applicant, and by using guidelines provided in the Mining Act. This review involves the assistance of several other government departments (i.e., Crown Lands, Agriculture, and Municipal Affairs & Environment) to insure that all concerns are thoroughly dealt with.

This year has seen applications for two such projects within the province; the first of these is for a 1000 ton/day gold/silver vat leaching operation proposed by Northumberland Mines Ltd. in the Murray Brook region of northeastern N.B. This is a gossan-type open pit deposit that will employ approximately 30 people for a minimum 6-year period. All the aforementioned data have been reviewed by the departments involved and the project has been issued an acceptance with conditions. Once these conditions have been met, then the applicant will be considered for a mining lease. The expected capital expenditure of this project is in the range of $16 000 000.

At the same time, Caribou New Brunswick Mining Ltd. has made application for a mining lease for the previously owned Anaconda property also in the northeastern portion of the Province. Appropriate documentation has been received and reviewed for a 2000 ton/day cut-and-fill mine producing a bulk zinc/lead concentrate. This operation will eventually employ 181 people and expend $35 000 000 of investment capital, much of it within the Province. Subsequent review of Caribou N.B. Mining Limited proposal has resulted in an Approval-in-Principle with conditions. Once these conditions are finalized, a mining lease may be issued.

In addition to these two new projects being reviewed, Gordex Minerals Ltd. continues to expand and implement new technology at its Cape Spencer property. They have changed their gold-extraction process from a zinc precipitate to a carbon pulp extraction and modified the heap-leach treatment to an earthen vat system. Last year they poured their first gold brick and this year have a planned production of 7500 ounces with an expansion to 11 000 ounces in 1988.

Heath Steele Mines has made application and received approval for an underground exploration program of the Stratmat Boundary property. This will consist of an 8 000' ramp and bulk sampling of 1000-2000 tons of ore for metallurgical testing. It is hoped that the results will be of sufficient grade, quantity, and processability to combine with the existing ore reserves at the mine site and mill at an approximate rate of 200 ton/day. The expected expenditure for this exploration program is approximately $5 000 000.

In addressing the second area of responsibility, that of promoting and developing N.B.'s mineral resource, Mine Engineering is directly involved with the Canada-New Brunswick MDA. Under the auspices of this agreement there are four ongoing projects. These are:

1. Rock Mechanics Program for Cut-and-Fill Mining

This is a project of three years duration being carried out in conjunction with the Potash Company of America in Sussex, N.B. The objectives of this project are to:

(a) ensure the overall stability of the mine

(b) minimize and understand local ground control problems in stopes and entry ways

(c) maximize safety - both to people and resource

(d) optimize extraction of the ore and increase productivity and efficiency

(e) improve measurement and analytical techniques

(f) transfer ideas and technology to Canadian mining industry

The total expected expenditure for this project will be \$762 000 of which the Canada-New Brunswick MDA will supply \$370 000.

The project is well underway with significant progress having been made in the installation of monitoring system and acquisition of material, and expertise for computer simulation and analysis.

2. Wire-Rope Testing

The principle objective of the project is to enhance the understanding of the basic capabilities of various mine-shaft wire-rope non-destructive test (NDT) instruments, and of the associated chart evaluation techniques, by means of a carefully controlled and well-documented series of laboratory and in-situ tests.

A secondary objective will relate to the regulatory aspects of NDT wire-rope testing in mine shafts. This will include matters pertaining to certification of operators and instruments, rope retirement criteria, and the like.

New Brunswick participation will consist of providing one or more test sites for the in-situ rope examinations. The expected expenditure for this project will be \$61 100.

3. Utilization of CO_2 for Automated Mine Ventilation

The overall objective of this project will be to investigate all parameters surrounding automation of the mine ventilation system at BMS.

The project will be divided into three phases; the first will be to define whether CO_2 alone or in combination with other key underground contaminants can be effectively used as an engineering control parameter for mine ventilation.

The second phase will relate directly to the results of Phase I and consist of identifying the necessary hardware, software, and transmission requirements for remote sensing and control.

Phase III represents pilot testing of the system at selected locations within the mine for trouble shooting and ensuring integrity before BMS proceed with full-scale implementation.

The total estimated cost of Phase I and II will be \$170 800 of which the Canada-New Brunswick MDA will fund \$68 800. The rest of the funding is through BMS and the Department of Supply and Services Unsolicitated Proposal Funds. The project is being coordinated by CANMET.

4. Mine Services Software Systems

The overall objective of this project will be development of an interactive multiple-user mine services software system. The idea being to collect, compile, analyse, and correlate all the different aspects of operational data generated from several sources of a mining operation, in an immediate time period such that the required information is still relevant.

The net result of this will be overall improved efficiency within the mining operation.

This will be a project of 3 years duration with a total expected expenditure of $286 500.

5. Use of Backfill in N.B. Potash Mines

The overall objective of this project is to evaluate the stabilizing effect of waste salt as backfill on mine openings in potash mines with the purpose of improving the capability of predicting ground behaviour to increase safety and potash productivity.

Phase I of this project has been successfully completed with the determination of engineering properties of waste salt backfill and host rock, and the effect of backfill on convergence and creep of mine openings by mathematical and numerical model.

Phase II is scheduled to begin shortly and will attempt to substantiate the findings in Phase I through field trial and in-situ monitoring.

The total expected value of this project will be $426 200.

PEAT AND COASTAL ZONE RESOURCES

Jacques J. Thibault, Geologist

PEAT

Two projects, funded under the Canada-New Brunswick MDA will have been completed by the end of 1987:

a) Survey of the uses of peat in agriculture - Open File Report 87-8

Detailed literature research on the use of peat as an additive in the agricultural field and the identification of applied research projects that may lead to a more extensive use of peat in agriculture.

b) Peat moss market study - Open File Reports 87-16(E), 17(F)

A report that determines how the peat moss market is presently structured in North America and that evaluates the potential for the further development of selected overseas markets.

A report summarizing the results of an investigation of the peat resources of New Brunswick was published as Open File Report 83-10.

A paper, entitled "Geology, processing and marketing of peat in New Brunswick" was presented at the CIM 89th Annual General Meeting in Toronto, Ontario.

COASTAL ZONE

Between September 10 and 14, 1986, the entire New Brunswick coastline was filmed. The first two segments are presently prepared for release as Geological Survey of Canada Open File: 1) Cap-Lumière to Point Escuminac, and 2) Saint John to Cape Enragé. The documents will be available in VHS or BETA format. Funding for this project was provided by the Atlantic Geoscience Centre, Dartmouth, Nova Scotia.

GRANULAR AGGREGATE RESOURCES IN NEW BRUNSWICK

A.A. Seaman, Quaternary Geologist

This year will see the completion of The New Brunswick granular aggregate inventory program, with the writing of the reports for the five areas mapped in 1986 (the Fundy Islands, 21 B/10, B/15; Saint George, 21 G/2; Hampstead, 21 G/9; Cape Spencer, 21 H/4; and Waterford/Salmon River, 21 H/6, H/11). In addition, the Quarriable Substances Act, and regulations thereunder, will be extensively revised, to permit better management of aggregate resources on Crown Lands.

A project to evaluate and forecast the aggregate market in New Brunswick, financed under the federal portion of the MDA, will complement the "Atlas of Granular Aggregate Resources, New Brunswick, "released this year.

ENERGY BRANCH

ACTIVITIES OF THE ENERGY BRANCH

Clint St. Peter, Energy Geologist

In January 1986, the Energy Secretariat was integrated with the New Brunswick Department of Forests, Mines and Energy (DFME). As a result, the Conservation and Alternative Energy Division of the Secretariat and the Energy Section of DFME have been amalgamated into the Energy Branch. Donald E. Barnett became the Director of the Energy Branch in 1987. The Branch is divided into a renewable and a nonrenewable resource section.

The nonrenewable resource section is responsible for the administration, management, investigation, and development of coal, oil, natural gas, oil shale, geothermal energy, uranium, etc.

In 1987, the Energy Branch continued to carry out Provincial studies on the Albert Formation oil shales under the supervision of Clint St. Peter. The Branch has retained management of energy resource-related studies previously initiated under the MDA. Among these are, (1) an oil shale beneficiation study underway at the Atlantic Coal Institute in Cape Breton, (2) an Albert Formation sandstone diagenesis investigation under Ali Chowdhury, and (3) an assessment of sedimentary facies and environment(s) of the sandstones at Stoney Creek Oil and Gas Field under Steve Foley. The latter two projects are being jointly supervised by Clint St. Peter of DNRE and Dr. J.P.A. Noble of the University of New Brunswick.

DIAGENESIS OF THE ALBERT FORMATION

A.H. Chowdhury, MDA

The Late Devonian to Early Carboniferous Albert Formation sandstones in the Moncton Subbasin of southern New Brunswick are mainly subarkosic quartz arenites and sublitharenites. The sandstones contain abundant intraformational carbonite clasts and volcanic clasts with laths of plagioclase phenocrysts. On the basis of ternary QFR plots, the sandstones are mainly derived from continental blocks and the detritus has a recycled orogenic provenance (Dickinson 1985).

Three sandstone sequences separated by shale/marlstone intervals have been recognized at Stoney Creek and in the Irving Chevron Hillsborough No. 1 well, 6 km south of Stoney Creek Oil and Gas Field. In this area, the Albert Formation increases in thickness to the south. A minimum burial of about 3 km is suggested for Albert sandstones at Hillsborough, which is believed to be near the depocenter of the subbasin (Figure 25).

Cements in these sandstones are primarily carbonate, clays, and quartz. To determine mineralogy, morphology, mutual relationships of different authigenic phases, precipitates were studied by thin-section petrography, SEM with an EDX analyzer and microprobe. Different generation of carbonate cements were separated and analysed for C and O isotopes to determine their origin and to establish a fluid-flow model on the basis of isotope gradient. Preliminary results on the isotopes of the carbonate cements throughout the basin indicate considerable homogeneity of their occurrence. C-isotope data for the cements suggest a dominant inorganic origin, with contribution from surficial bacterial oxidation in shallow horizons and skeletal materials in the deeper sections.

Carbonate veins, which range from brecciated to undeformed and either parallel or inclined to bedding, were studied by thin-section petrography and for C and O isotopes. Combined petrographic and isotope data suggest development of two generations of fractures in the Moncton Subbasin. Most of these fractures are late, postdating all the cements.

Quartz cements, point counted from thin sections, are estimated to make up a maximum of 4% of the rocks. Samples from surface outcrop and shallow sections, show no pressure solution, and point counts show a quartz-cement content of about 2%. In the deeper sections, about half of the quartz cement is pressure solution in origin.

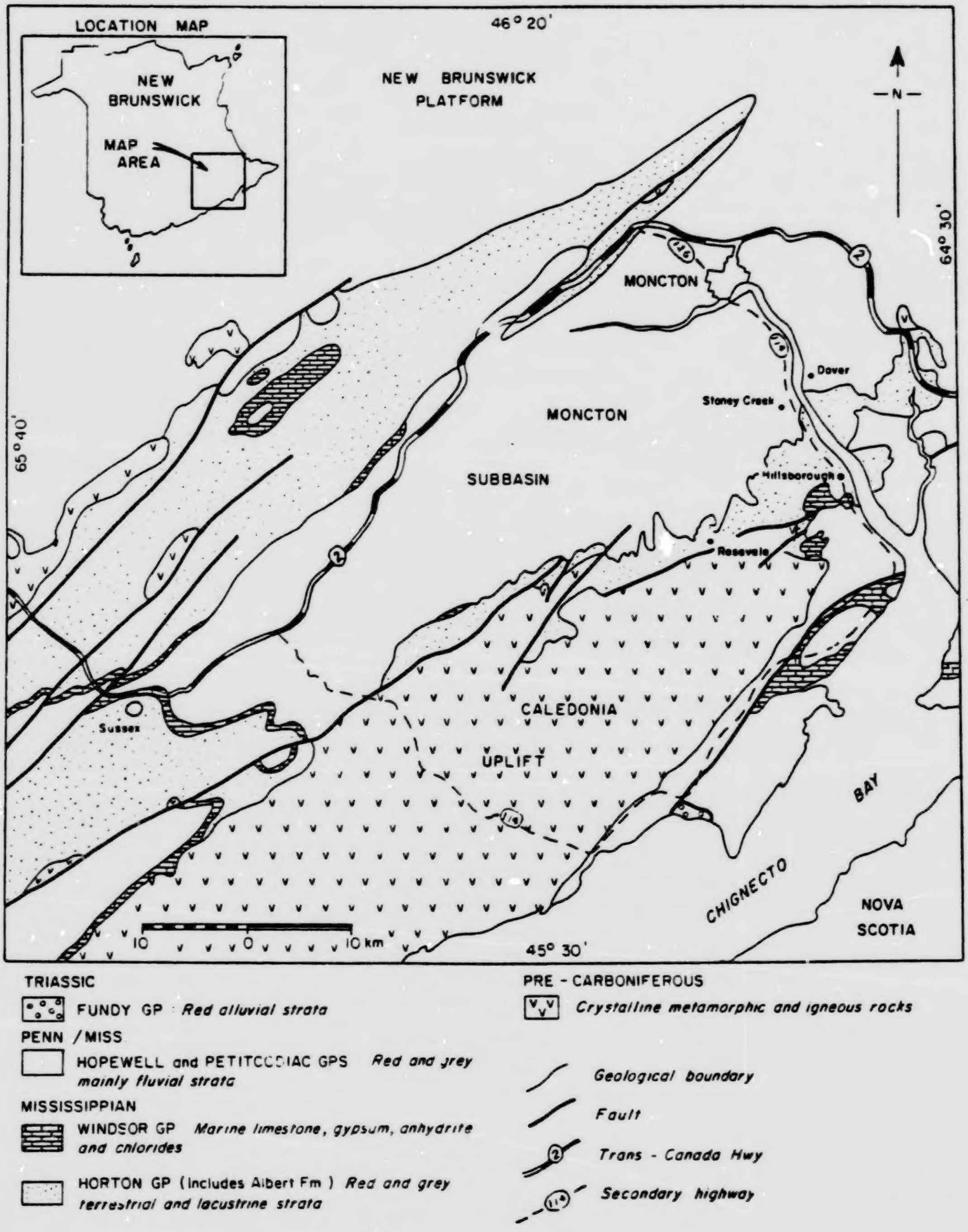

FIGURE 25. Generalized geology of the Moncton Subbasin (after St. Peter 1987).

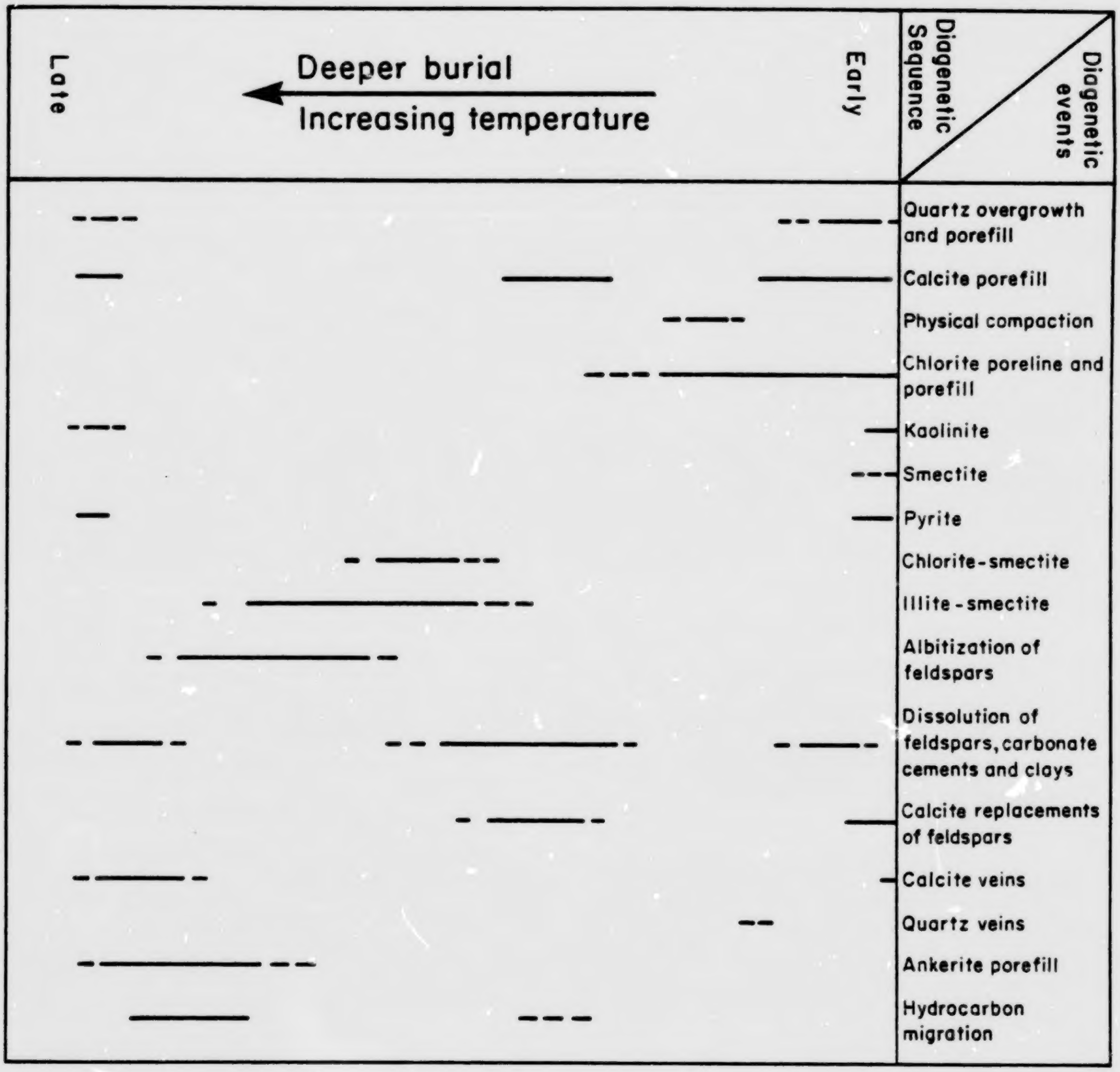

FIGURE 26. Sequential development of diagenetic features in Albert Formation sandstones based on paragenetic sequence. The vertical bars denote interpreted relative depth range and significance of major diagenetic events.

Less than 2 um clay fractions were studied by XRD to confirm identifications on SEM-EDX. In Albert Formation sandstones, chlorite, illite, kaolinite, and mixed-layer chlorite-smectite, illite-smectite are the major clay minerals present.

On the basis of the degree of albitization of feldspar, illite crystallinity, and ankerite cement zonation, preliminary results suggest uplift and erosion of the part of the Albert deposits in the south and east parts of Subbasin from Rosevale to Dover (Figure 25).

On the basis of mutual textural relationships of different authigenic phases, a paragenetic sequence of authigenic minerals in the Albert Formation sandstones has been determined (Figure 26).

Porosity in Albert Formation sandstones, ranging from 10-20% is mainly secondary resulting from dissolution of feldspars, carbonate cements, and clays. Microporosity (less than 5 um) in clays, determined from SEM-EDX observations, may constitute as much as 50% of the total porosity. Since secondary porosity does not necessarily ensure intercommunicating pore spaces, permeability in these sandstones is variable. Major sections of these sandstones are tight, but some show permeability as high as 3000 mD.

A comprehensive burial history of the subbasin will be modelled based on vitrinite reflectance data, illite crystallinity, ankerite cement zonation, and the degree of albitization. Source rock and liquid hydrocarbon characterization on the basis of gas chromatogram matching and geochemical fossils will also be examined.

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THE STONEY CREEK OIL AND GAS FIELD PROJECT (MDA)

Steven L. Foley
Research Associate, UNB

The Stoney Creek Oil and Gas Field is a producing field located 16 km south of Moncton, New Brunswick. The hydrocarbons are reservoired in sandstones of the Lower Carboniferous Albert Formation. The Albert Formation is a lacustrine and associated fluvial-deltaic sequence deposited in an elongated north-east-trending basin known regionally as the Moncton Subbasin (Pickerill and Carter 1980). The Albert Formation is the middle grey formation of the Horton Group and is overlain by redbeds of the Moncton Formation (Horton Group) and underlain by redbeds of the Memramcook Formation (Horton Group). In the vicinity of Stoney Creek the Horton is overlain unconformably by the Enragé Formation. The oil and gas field is located along the south flank of the Westmorland Uplift (Figure 27) which bifurcates the Moncton Subbasin in the east. Limited exposure of the uplift indicates a coarse crystalline, porphyritic granite terrain (Pickerill et al. 1985).

This project has entered its second year of study. During the last year, 25 wells drilled by New Brunswick Gas and Oil Fields Ltd., and related companies, have been relogged. The lithotype data presented in the graphic logs have also been stored on microcomputer. An IBM operating system supported program, LOTUS 123, has been utilized for data storage and manipulation. The use of this program has also allowed the data conversion of recently drilled wells at Stoney Creek (Irving/Chevron East Stoney Creek No. 1, Stoney Creek No. 1, and Hillsborough No. 1) into the program format, enabling better comparison between these wells and the original wells at Stoney Creek.

Cross-sections have been constructed along N-S and E-W orientations in the Stoney Creek Oil Field, allowing a three-dimensional view of the reservoir sandstones. The Albert Formation appears to dip toward the south at 10 to 25 degrees. In the northeast of the oil and gas field, the top of the Albert Formation has been eroded by the Enragé unconformity. Redbeds of the Hillsborough and Weldon Members (Moncton Formation) overly the Albert Formation throughout the remainder of the Field and thicken quickly south as a wedge between the Enragé Formation and the top of the Albert.

The average depth of the original wells drilled at Stoney Creek is between 800 and 1000 metres. The thickening of Moncton Formation redbeds to the south has limited the information on the Albert Formation on the southern margin of the oil field. Well N.B.G. & O. 84 in the extreme northeast of the oil field is the only original well (relogged to date) which cuts the complete Albert section; intersecting 720 metres

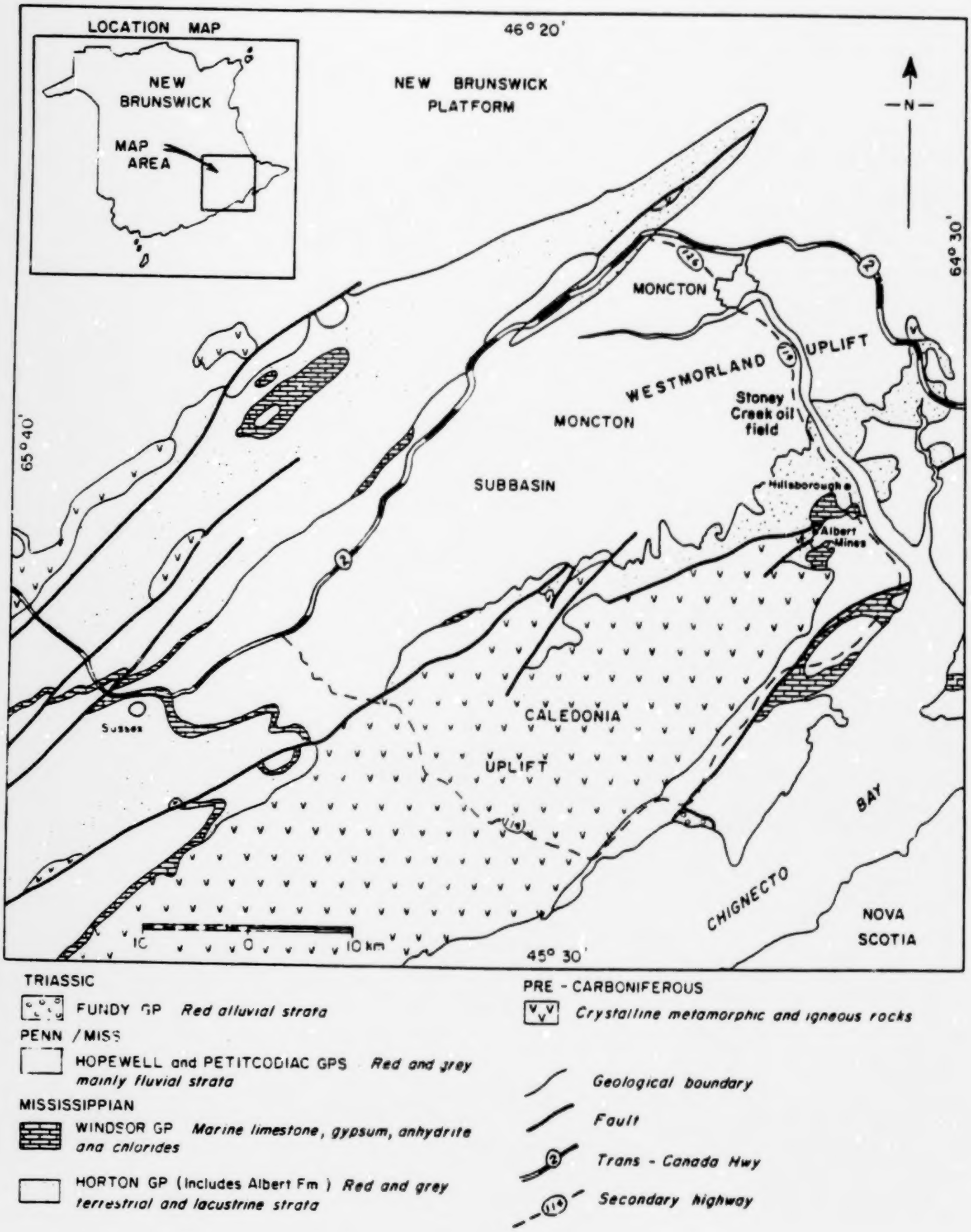

FIGURE 27. Generalized geology of the Moncton Subbasin (after St. Peter 1987).

of Albert Formation. Irving/Chevron East Stoney Creek No. 1 and Stoney Creek No. 1 also cut the complete Albert section and both record approximately 1220 metres of Albert Formation. These thicknesses and their relationship to the other wells in the field indicate an obvious thickening of the formation to the south.

Correlation of sandstone units between wells has allowed the definition of sandstone distribution in the Stoney Creek field. The sandstones within the Albert appear to thicken toward the south and centre of the oil field. Chip logging limits the information on established sandstone intervals to relative percentages. The generation of sandstone/shale ratios over specified depth intervals gives a more complete picture of sandstone distribution within the field. These ratios back up the graphic logs by showing an increase in sandstone toward the south and centre of the field. The distribution of sandstone in the oil field is very perplexing when related to the distribution of the Albert Formation as a whole. As expected the Albert shales thicken to the south toward the deeper part of the basin which should be away from the source area. The Albert Formation sandstones also thicken to the south. This raises the question, what is the role of the Westmorland Uplift to sediment distribution and sandstone geometry within the Stoney Creek Oil Field? A rapid thinning of the Albert to the north, along the flank of the Westmorland Uplift indicates that the uplift controlled the accumulation of the Albert sediments. The Albert Formation sandstones at Stoney Creek are generally arkosic and volcanic fragments are conspicuously absent, therefore these sediments are unlikely to have been derived from the Caledonia Uplift (Figure 27); a greenstone terrain to the south (Pickerill and Carter 1980). In a stable basin, the elastic coarse fraction should thin away from the source (Walker 1984). In an unstable basin, the sediment distribution is controlled by structural trends and rate of subsidence. Drainage systems tend to focus along axial trends (Miall 1981). The Moncton Subbasin, during the Lower Carboniferous, was a structurally controlled elongated basin. The depocenter would have been located along the axial trough in an area of maximum subsidence. If we assume the Westmorland Uplift was a positive feature, sediments would have been shed off that high to the south and west, into the axis of the basin. The depocenter was probably located south of Stoney Creek. Sands would have thickened off the Westmorland Uplift, focusing the major accumulation in the depocenter. The Stoney Creek Oil and Gas Field is probably located up-dip of the major sand accumulation along the flank of the uplift.

A third Irving/Chevron well was incorporated into the computer data base. The Irving/Chevron Hillsborough No. 1 well was drilled 6 km south of the Stoney Creek Oil and Gas Field near the town of Hillsborough. The logs from Hillsborough No. 1 were studied in order to gain a better understanding of the regional distribution and geometry of Albert sandstones south of the oil field. This information may be the key to locating the source area. The Albert Formation was intersected between 1300 metres and total depth of 3013 metres. The graphical computer profile of the Albert section between the 1300- and 2000-metre interval closely resembles the Albert Formation signature in the Stoney Creek Oil and Gas Field. The upper 700 metres of the Albert Formation in the Hillsborough well can be correlated with the Albert sequence in the Stoney Creek field. The bottom 1000 metres in Hillsborough No. 1 is dominantly sandstone with intervals reaching thicknesses of up to 200 metres. Lithologically, these sands are similar to the rest of the section. The large proportion of sand in Hillsborough No. 1 may be a result of its location near the basin depocenter. If the source of the sand is in the south, in Nova Scotia as indicated by Howie (1979) and Pickerill and Carter (1980), and it is assumed that the sandstone thickens toward the source, then there must be a very thick laterally continuous Albert sandstone between Stoney Creek and Nova Scotia. However, in the Albert Mines area, 10 km south of Stoney Creek, the Albert Formation is dominantly shale (Greiner 1962). The occurrence of a thick sandstone sequence between Stoney Creek and Nova Scotia has never been documented.

In conclusion the available data strongly suggest that the source of the Albert sandstones was not to the south, in either the Caledonia Uplift or in Nova Scotia.

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OIL SHALES AT ALBERT MINES (PROV)

Clint St. Peter, Energy Geologist

Oil shales were first identified along Frederick Brook by Dr. Abraham Gesner (1841). The area later received the name Albert Mines following 1849 when a vein of black vitreous solid bitumen - called albertite - was discovered cutting the oil shales along the Brook (Figure 28). The albertite vein was mined along a northeasterly strike for 850 m and to a depth of about 400 m (Ells 1909; Cunningham-Craig 1916; Wright 1922).

Since the discovery of oil shales at Albert Mines, various estimates of reserves have been made. Ells (1903) considered the quantity of oil shale practically unlimited. Wright (1922) established, from tunnel channel samples and surface grab samples, that the oil shale beds vary considerably in grade. Wright (ibid) mapped the location of the five promising oil shale beds near Frederick Brook and suggested a deposit containing millions of tons. Alcock (1948) described the results of a 1942 Federal Government drilling program wherein 4000 m of core was drilled in 36 holes. By disregarding stratigraphy and structured complications, Alcock (1948) determined that in a block 730 m in length (NE-SW) by 490 m in width (NW-SE) and to a depth of 120 m that there are 91 000 000 tonnes of oil shale. The average yield of this shale is 53 litres/tonne and would provide about 30 000 000 barrels (bbls) of shale oil.

Macauley and Ball (1982) calculated reserves using Fischer Assay data on continuously sampled core drilled by Atlantic Richfield Company and Canadian Occidental Petroleum Limited. They estimated that the highest grade zone in the area is about 60 m wide and that in a block 1200 m in length to a depth of 600 m, this high-grade zone contains an in-situ reserve of 67 300 000 bbls of shale oil.

All previous oil shale reserve estimates at Albert Mines have disregarded the complications caused by faults that are known to affect the strata. For example, it has been known for over 100 years that the albertite vein occupies a fault breccia zone (Dawson 1853; Milner 1912; Cunningham-Craig 1916). The oil shales are in places deformed and brecciated (Wright 1922; Alcock 1948; Macauley and Ball 1982). Faults (apparently with little displacement) offset the albertite vein in the underground workings (Dawson 1853; Hitchcock 1865).

A recent compilation of all available surface and borehole structural data has led to a more complete understanding of the three-dimensional geometry of the highest grade oil shale bed (Figure 28). The major fold affecting the sequence is a

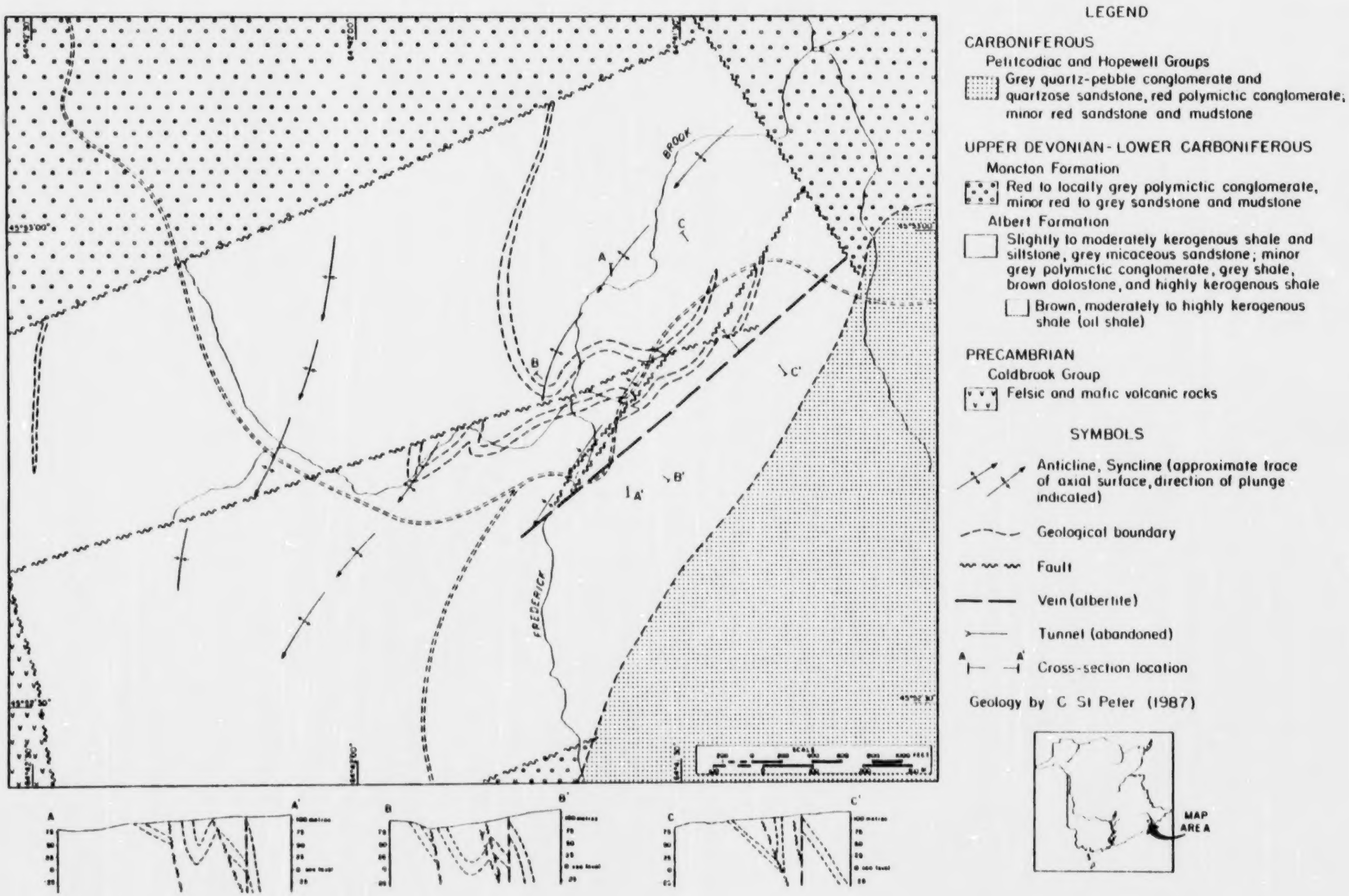
LEGEND
CARBONIFEROUS
Petitcodiac and Hopewell Groups
Grey quartz-pebble conglomerate and quartzose sandstone, red polymictic conglomerate; minor red sandstone and mudstone
UPPER DEVONIAN - LOWER CARBONIFEROUS
Moncton Formation
Red to locally grey polymictic conglomerate, minor red to grey sandstone and mudstone
Albert Formation
Slightly to moderately kerogenous shale and siltstone, grey micaceous sandstone; minor grey polymictic conglomerate, grey shale, brown dolostone, and highly kerogenous shale
Brown, moderately to highly kerogenous shale (oil shale)
PRECAMBRIAN
Coldbrook Group
Felsic and mafic volcanic rocks
SYMBOLS
Anticline, Syncline (approximate trace of axial surface, direction of plunge indicated)
Geological boundary
Fault
Vein (albertite)
Tunnel (abandoned)
Cross-section location
Geology by C St Peter (1987)
MAP AREA
BROOK
FREDERICK
A
A'
B
B'
C
C'
SCALE

FIGURE 28. Geology of organic-rich oil shale bed at Albert Mines, New Brunswick.

south-plunging anticline (Young 1912; Wright 1922; Alcock 1948). The significant faults cutting the strata are steep northeast- and east-northeast-trending structures. The interpreted map pattern on the high-grade bed suggests that the shales on the south side of the faults have moved upward and perhaps right-laterally with respect to those on the north side. The main east-northeast-trending fault is seen to repeat the high-grade bed. This fault effectively doubles the quantity of high-grade shale available at the surface.

Oil shale reserves in the highest grade bed at Albert Mines have been reassessed using the structural model described above. The bed has an average thickness of 19.5 metres. This was determined by using the core axis to bedding angles in twenty-five holes. The bed has an average yield of 94.7 litres of shale oil/tonne of rock. For this bed, there are to depths of 100 m and 500 m respectively, 5 700 000 and 22 600 000 bbls of shale oil in place.

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GEOLOGICAL SURVEY OF CANADA

FIELD RELATIONS, PETROLOGY, AND AGE OF THE POINT WOLFE RIVER AND BONNELL BROOK PLUTONS AND ASSOCIATED METAMORPHIC ROCKS, CALEDONIAN HIGHLANDS, SOUTHERN NEW BRUNSWICK[1]

Sandra M. Barr and Chris E. White
Department of Geology, Acadia University
Wolfville, Nova Scotia BOP 1XO

The Point Wolfe River and Bonnell Brook plutons are the largest granitoid intrusions in the eastern Caledonian Highlands of southern New Brunswick (Ruitenberg *et al*. 1979). They intruded metavolcanic and metasedimentary rocks assigned to the Coldbrook Group of probable Late Precambrian age (Kindle 1962; Ruitenberg *et al*. 1979). The Caledonian Highlands are generally considered to form a typical part of the Avalon terrane of the northern Appalachians (e.g., Nance 1987).

As part of a continuing study of plutonic and associated metamorphic rocks of the eastern Caledonian Highlands, the Bonnell Brook pluton and the southwestern part of the Point Wolfe River pluton and their country rocks were mapped and sampled for petrological studies during the summer of 1987. The 1987 map area adjoins the areas mapped during 1986 and 1985 (Figure 29).

This study has shown that the Point Wolfe River pluton is composite, consisting of six map units which are interpreted to be comagmatic: quartz diorite/tonalite, quartz monzodiorite/tonalite, Pollett River granodiorite, Old Shepody Road quartz porphyritic granodiorite, Blueberry Hill granite, and Gowland Mountain granite porphyry. The Pollett River granodiorite comprises most of the northeastern portion of the pluton whereas the Old Shepody Road quartz porphyritic granodiorite forms most of the southwestern part. Toward its southwestern margin, it has been intruded by abundant fine-grained granite that may be related to the Bonnell Brook pluton to the west. Although heterogeneous dioritic rocks occur along its southern margin, the Bonnell Brook pluton consists mainly of relatively homogeneous leucocratic hornblende-biotite granite, locally granophyric, and appears to have been emplaced at a high crustal level. A smaller intrusion of similar composition lies northwest of the main Bonnell Brook pluton. Other small intrusions in the map area include the Alma diorite, Fortyfive River granodiorite, and Goose Creek leucotonalite described by Barr (1986), all of which are located southeast of the Point Wolfe River pluton, and the Mechanics Settlement diorite/gabbro

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[1] Contribution to Canada-New Brunswick Mineral Development Agreement. Project carried by the Geological Survey of Canada.

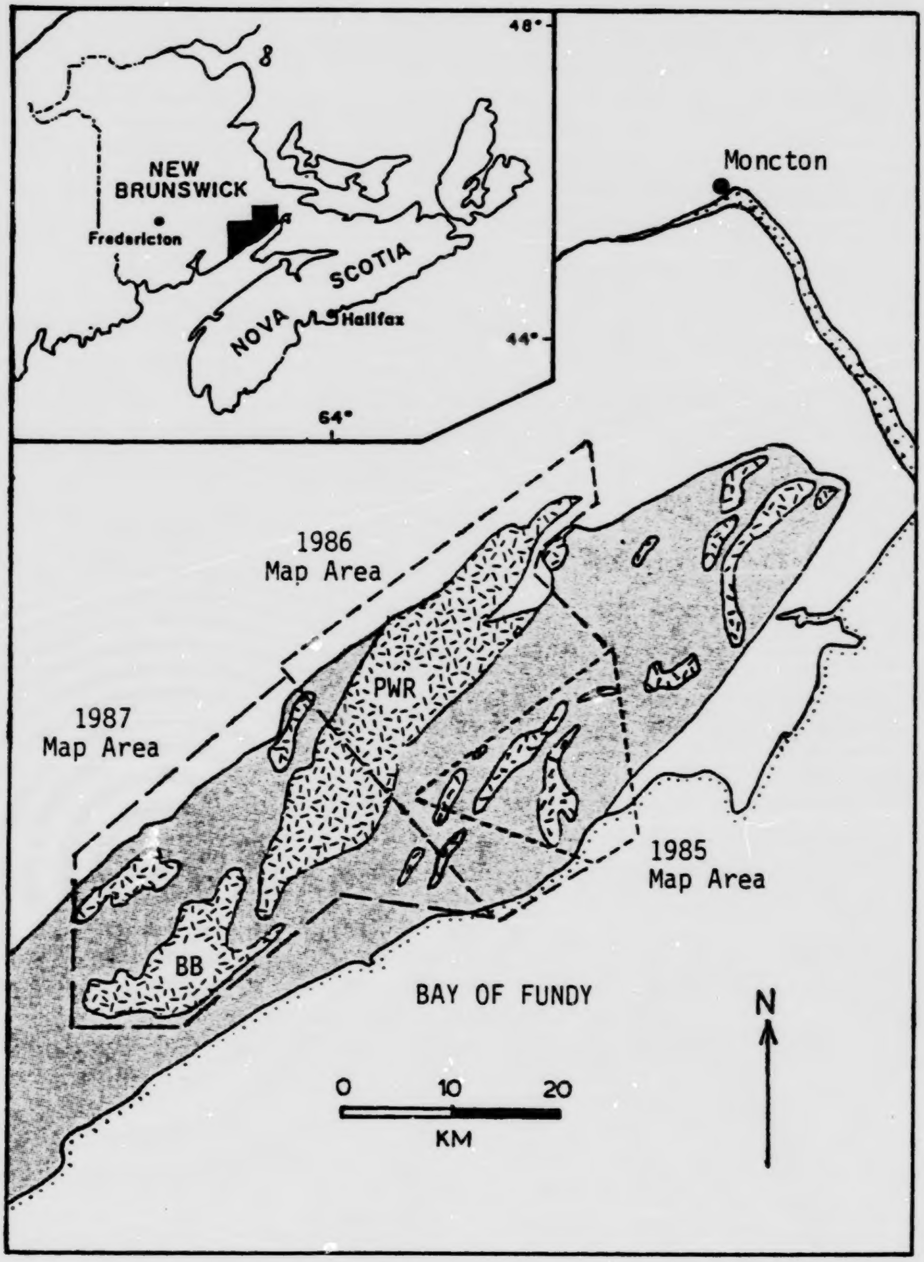

FIGURE 29. Index map showing 1985, 1986, and 1987 study areas.

located northwest of the Point Wolfe River pluton. Rubidium-Sr whole-rock isochrons and K-Ar (amphibole) ages from the Fortyfive River granodiorite and the Alma diorite (Barr 1986) and the Pollett River granodiorite indicate ages of about 600 Ma. A younger Rb-Sr isochron age of 530 ± 16 Ma has been reported from the Bonnell Brook pluton (McLeod 1986). The plutonic rocks of the eastern Caledonian Highlands appear to form a comagmatic expanded "I-type" suite, generated in a volcanic arc environment in primitive continental crust during the Late Hadrynian.

A preliminary stratigraphic sequence has been defined in the metavolcanic and metasedimentary rocks in the map area. From bottom to top it consists of mafic to intermediate volcanic rocks, fine-grained tuffaceous and volcanogenic sedimentary rocks (now slates and phyllites), arkosic sedimentary units, rhyolitic flows and ignimbrites, amygdaloidal basalt flows, and mafic to intermediate tuffs and flows interlayered with flow breccia, chert, and fine-grained turbidites. The Teahan Zn-Cu-Pb-Ag-Au prospect is hosted in the fine-grained tuffaceous and sedimentary unit, and current prospecting for gold appears to be concentrated in the turbiditic units near the top of the inferred stratigraphic succession. Geochemical data indicate that mafic flows in the sequence are volcanic-arc tholeiites, formed in a relatively primitive subduction environment.

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RECONNAISSANCE DRAINAGE-SEDIMENT AND WATER SURVEYS IN NEW BRUNSWICK[1]

P.W.B. Friske

As part of the Canada-New Brunswick MDA (1984-89) regional reconnaissance drainage-sediment (stream and lake) and water surveys are being planned and implemented by the GSC in consultation with the NBDNRE, Geological Surveys Branch and the New Brunswick Prospectors and Developers Association.

To date three surveys have been undertaken (Figure 30). Results of the 1986 stream-sediment and water survey, covering 2500 km^2 in the Bay of Fundy coastal area (Figure 30) were released on June 24, 1987 as GSC Open File 1355, consisting of 25 maps and 119 pages of text. Data on Zn, Cu, Pb, Ni, Co, Ag, Mn, Cd, Fe, Mo, V, As, Hg, U, LOI (loss-on-ignition), F, Sb, W, Ba, Sn, and Au are available for the sediments, as well as U, pH, and F for the waters. Approximately 4630 acres were staked following the release (up to late August) mainly in areas of anomalous responses in gold and/or associated pathfinder elements.

Sample collection for a third drainage-sediment and water survey, located in southern New Brunswick (Figure 30), was completed in early September, 1987. Unlike the previous surveys, both stream and lake sediment and concomitant waters were collected from the 3900 km^2 survey area (average sample density 1/3.0 km^2). Stream-sediment and water samples were collected from 1011 sites by K.D.A. Whaley and Associates, while the collection of 301 lake-sediment and water samples was carried out by GSC personnel. Both sediment sample media will be analysed for the same suite of elements as last year's survey and the data will be released as GSC Open File 1638 in June or July 1988.

Although this year's work marks the first time that a systematic lake-sediment and water sampling program has been undertaken in New Brunswick, this type of geochemical survey has been used successfully for mineral exploration throughout Canada (including Nova Scotia and Newfoundland) for a number of years. During the course of this summer's lake-sediment sampling in New Brunswick it was noted that a well-developed gyttja occurs within the centre lake basin of the vast majority of lakes sampled. This fine organic-gel is the preferred type of lake-sediment medium to encounter and augurs well for the applicability of lake-sediment surveys to mineral exploration in New Brunswick.

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[1] Contribution to Canada-New Brunswick Mineral Development Agreement. Project carried by the Geological Survey of Canada.

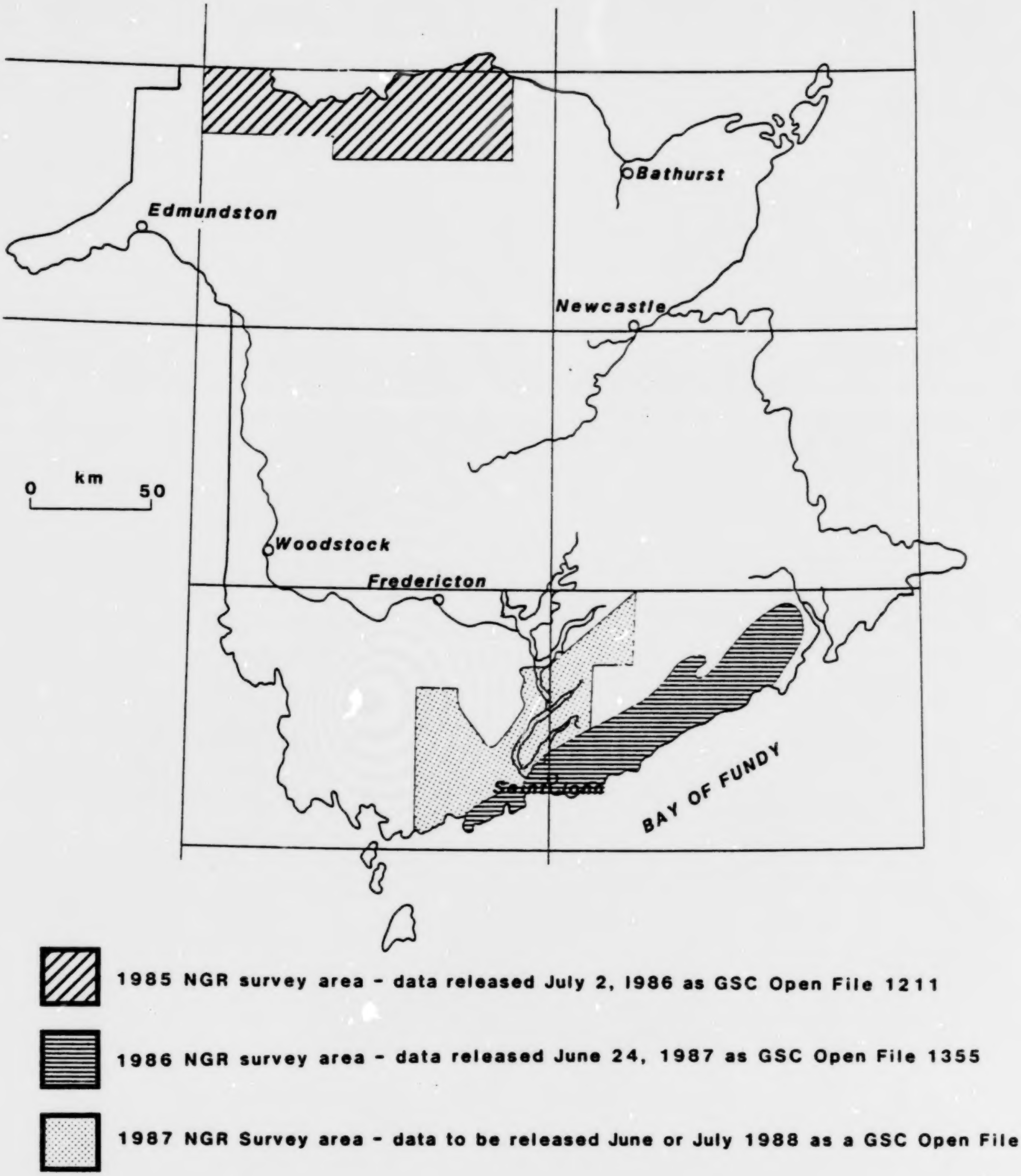
Bathurst
Edmundston
Newcastle
0 km 50
Woodstock
Fredericton
Saint John
BAY OF FUNDY
1985 NGR survey area - data released July 2, 1986 as GSC Open File 1211
1986 NGR survey area - data released June 24, 1987 as GSC Open File 1355
1987 NGR Survey area - data to be released June or July 1988 as a GSC Open File

FIGURE 30. National Geochemical Reconnaissance survey coverage in New Brunswick.

As way of a quick orientation study, 26 lake-sediment samples were collected from the Cape Spencer area. Data from these samples will be of interest as a guide to interpretation of the regional data. Results will be published as soon as they are available.

POTENTIAL FOR URANIUM AND ASSOCIATED ELEMENT POTENTIAL IN THE MIRAMICHI ANTICLINORIUM[1]

H. Hassan
UNB Geology Department
Fredericton, New Brunswick

Investigation on the metallogenesis of uranium in New Brunswick, initiated by H. Hassan and the late W.E. Hale, is continuing.

Of the seven metallogenic uraniferous domains established in the first phase of the project, the Miramichi Anticlinorium was identified as the most promising target for uranium exploration.

In Phase II, polymetallic vein-type uranium deposits in the North Pole Pluton (Miramichi Anticlinorium) were studied in detail to determine favourable geological, geochemical, and geophysical signatures for uranium mineralization. Some of these features were used to identify three other favourable granitic plutons in the Miramichi Anticlinorium.

At present (Phase III) the Burnthill, Trout Brook, and Dungarvon plutons, are being investigated in detail to further establish their potential for vein-type uranium mineralization.

LITHOGEOCHEMICAL STUDY OF RED MANGANIFEROUS SLATE AND BLACK SLATE-CHERT IN MIRAMICHI ZONE, NEW BRUNSWICK[1]

D.W. Hattie and M.D. Connell
Geosleuths Mineral Exploration Services
Box 480, Sackville, N.B.
EOA 3CO

In July 1986, Geosleuths began to study and sample, throughout the Miramichi tectonic zone, mid-Ordovician chemical sedimentary rocks that are approximately time-equivalent to felsic and mafic volcanism along the whole zone, and in part to the time of base-metal ore deposition in the Bathurst area.

During December, 1986 and January, 1987, numerous samples of red and black slates and cherts, and various facies of iron formations were collected from the drill-core storage facilities of CIP Inc., Brunswick Mining and Smelting, Heath Steele Mines, Key Anacon Mine, and N.B. Minerals and Energy Division at Fredericton and Madran. From these samples, and those already collected from outcrops (Hattie and Connell 1986), a total of 276 were selected for shipment to X-Ray Assay Laboratories Ltd. All the samples were analysed for Loss on Ignition, and for % SiO_2, TiO_2, Al_2O_3, total Fe as Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, and Cr_2O_3 and for ppm Ba, Nb, Rb, Sr, Y, Zr by X-ray fluorescence. The elements Li, Be, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Th, Mo, Ag, Cd, Sn, Sb, Te, W, Pb, Bi, and U were determined in ppm by ICP/MS. Arsenic was measured in ppm by atomic absorption and Au in ppb by fire assay/DCP. Among the samples 191 were chosen for analysis by wet chemistry for % FeO, H_2O, and ppm F, and by X-ray fluorescence for % S and ppm Cl. Data for many of these oxides and elements in 65 samples of iron formations obtained from the Bathurst area by S.I. Saif in 1978 (see Saif 1980) were incorporated into the current study.

UTM coordinates and codings for rock types and geological settings were added to the data received on computer tape from X-Ray Assay Laboraties Ltd. With the advice and skills of Michael Lodin, the data were entered into the mainframe computer at UNB, and a great variety of statistical tables, inter-element plots, histograms, and maps were produced. Univariate statistics, and correlation coefficients were calculated for the whole population, and for three sub-populations, composed of 1) red slates and cherts, 2) iron formations and green cherts, and 3) black slates and cherts. These outputs were discussed with Drs. D.J. Mossman and J. Greenough of Mount Allison University.

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A notable correlation, in all sub-populations, is that between Al_2O_3 and TiO_2, which compares with published literature on deep-ocean sediments (Marchig et al. 1986), on Mesozoic and Tertiary cherts from Japan (Matsumoto and Iijima 1983), and on Australian Proterozoic and other iron formations (Davy 1983). The details of the relationship remain enigmatic, but must involve both biotite and sphene.

In the iron formation sub-population, there is a clustering among CaO-Fe_2O_3-P_2O_5-F-Sn-Pb-Zn-Bi, and among Au-As-Sb, though only Pb and Zn approach economic concentrations. Elevated phosphate, with associated metals, is limited to the Brunswick #6 and #12 areas, and the vicinity of Heath Steele mine. In Recent sediments of the Black Sea, and along the East Pacific Rise, the P_2O_5-Fe_2O_3 tie is documented as an inorganic chemical relationship (Berner 1973; Shaffer 1986).

The ratio of Y to P_2O_5 divides the iron formation sub-population definitively into two groups, one with Y, the other with P_2O_5, in the same way that this ratio divides samples from the East Pacific Rise. There, it has been interpreted by Marchig et al. 1982 that the two groups are 1) deep-sea sediments and 2) sediments modified by passage of hydrothermal solutions. We suggest that the difference is between rapidly buried sediments and those that have been long exposed on the sea floor and taken up ions from sea water.

Among the iron formations, it appears that MgO, K_2O, Al_2O_3, TiO_2, Cr, Zr, Th, and Li were controlled mainly by influx of volcanic ash or fine clastics into the chemical sediments.

Vanadium is enriched, up to 2700 ppm, in certain sulphitic black slates, and in some samples of iron formation, in accordance with the geochemical literature. Gold (except in the fringes of the major sulphide deposits, and the Devils Brook showing), and uranium were discouragingly low throughout the samples. Platinum-group metals were not determined.

The site, other than the major known sulphide deposits, to which economic attention is drawn by this study is the Devils Brook "Pinnacle" copper showing. From field observations, this outcrop of chalcopyrite-pyrrhotite-magnetite-bearing black chert, flanked by black slates and sandwiched between basalt flows which are in part intensely carbonate-altered, appears to be a "black smoker" deposit. Our chemical data show that Sn, Bi, Te, Co, Mo, and Au (up to 130 pb) are higher than most other samples, and indicate that the showing is related to a once virile hydrothermal system. While geophysics and drilling have been done, previous workers assumed a north-east strike, rather than taking into account the need to use close-spaced lines suited to the north strike, chopped by east-north-east-striking faults.

D.V. Venugopal described 112 thin sections and 10 polished blocks. A number of garnet samples were selected by Venugopal and analysed by microprobe at the Geological Survey of Canada, Ottawa. Dr. R.K. Pickerill of the University of New Brunswick reviewed many of the thin sections of clastic rocks with a view to interpretation of provenance, but found them to be too structurally disturbed or thermally recrystallized for such study.

Microfossils were recognized by Venugopal from three sites within the Bathurst area. At the Willet sulphide showing, black slate from within the felsic volcanic rocks of the Tetagouche Group included nodules of calcareous algae. Radiolaria are present in red chert on the Tetagouche River 4 km east of Rocky Turn, and in red mudstone from the north shore of Canoe Landing Lake; in both cases in sedimentary rocks between thick basalt units. The microfossils were judged by Drs. R.K. Pickerill and J.P.A. Noble to be too poorly preserved to be precisely identified.

During the first half of 1987, field observations and thin-section data were merged into descriptive text for each sampling site, and maps prepared, usually at two scales, to show site locations (between 1:10 000 and 1:25 000 scale) and rock relations in outcrops (scales of 1:500 to 1:2000). Overview text has been prepared on regional setting and stratigraphy, analytical methods, statistical techniques, and interpretation. The whole package is being edited and upgraded for release as an Open File Report. A computer tape of the data will be available.

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DRIFT PROSPECTING OVER THE MIRAMICHI ZONE: A SUMMARY OF ACTIVITIES, 1985-1987[1]

Michel Lamothe[2]
Geological Survey of Canada
Ottawa, Ontario K1A 0E8

The drift prospecting project carried by the Geological Survey of Canada enters its last year of activity. Since June 1985, field and laboratory research has focused on the lithology and geochemistry of till, particularly in the vicinity of the mineralized Miramichi Zone. The objectives of this project are to document ice-flow history and glacial transport in central and northern New Brunswick as well as providing the industry with a geochemical data base.

Field work is now completed over the following map sheets:

21 G/13(partial = p), 21J/2, J/3, J/4, J/6, J/7, J/10, J/11(p), J/14(p), J/15, J/16; 21 O/1, O/2, 0/3(p), 0/6(p), O/7, O/8, O/16; 21 P/4(p), P/5, P/12 and P/13.

These areas have been surveyed as far as access permits. A total of 4000 samples of surficial till have been collected (average sampling density is 1 sample per 10 km^2) and approximately 200 striated sites are now being compiled.

The overburden drilling project, which was completed last January, recovered 4000 feet of core, one-third of which was composed of till and sand for geochemical analysis (300 samples). A trenching program has been initiated over the tin-bearing granites of central New Brunswick, in the vicinity of the Dungarvon disintegration moraine area, and between Big Bald Mountain and Sevogle River. Seven hundred samples of till have been recovered from these trenches.

Stratigraphical investigations reveal the presence of at least two till sheets, and possibly three, in a few localities, suggesting complex glacial transport for the thin and discontinuous till sheet generally observed over the Miramichi Zone.

The clay-sized fraction of every sample of till is analysed for 16 elements (e.g., Pb, Cu, Zn, Ni, Cr, Sn, W, Mo, H, Sb, Ur, As, Ag, ...). A clay-plus-silt fraction is also recovered and sent for gold analysis. Detailed field investigations and till sampling were conducted in the vicinity of three metallogenic environments: the Elmtree gold district, the massive sulphides of the Heath Steele mine area, and the Devonian Sn-W-Mo-granites of central New Brunswick. Large samples of till are being partitioned into 8 different grain sizes. Aliquots of these are sent for geochemical analysis and the heavy minerals are recovered and identified.

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[1] Contribution to Canada-New Brunswick Mineral Development Agreement. Project carried by the Geological Survey of Canada.

[2] Present address: Départment des Sciences de la Terre, Université du Québec à Montréal, Montréal, H3C 3P8.

Public release of the geochemical results will be in the form of four open file reports covering the different sampling programs.

PLATINUM-GROUP-ELEMENT ENVIRONMENTS IN NEW BRUNSWICK[1]

A. Dogan Paktunc
Geological Survey of Canada
Ottawa, Ontario K1A 0E8

Investigations concerning platinum-group-element (PGE) potential of the mafic and ultramafic intrusive rocks in the New Brunswick Appalachians were carried out during the 1987 field season. Localities investigated are shown in Figure 31.

Almost all the known platinum-group-element deposits and occurrences are associated with some form of Ni-Cu sulphide and/or chromite accumulations in mafic and ultramafic intrusions, most of which are layered. In such associations, pegmatitic segregations, zones containing hydrous phases, Cl- and CO_2-rich fluid phases and graphite appear to provide useful criteria in delineating platinum-group-element concentrations. Other features of interest include structures such as layer disruption, brecciation, and shearing.

The St. Stephen (Paktunc 1985), Portage Brook, Goodwin Lake-Maliseet Mountain, and Mechanicsville intrusions have features that are commonly observed in the PGE deposits associated with magmatic Ni-Cu sulphides (Table 3); therefore, it is possible that these intrusions may carry significant PGE concentrations. The Stewarton Complex may form a potential candidate for the magnetite-ilmenite type (A3, Table 3). The ultramafic and mafic rocks occurring along the Rocky Brook - Millstream Fault and in Lacana's Elmtree property may be regarded as possible hydrothermal environments for platinum-group elements.

PORTAGE BROOK:

The Portage Brook intrusion occurs in the Miramichi tectonic zone and is located approximately 100 km west of Bathurst. Detailed mapping (at 1:10 000 scale) and sampling of the intrusion, which started in 1986 (Paktunc 1986), was completed. The intrusion is well layered and is made up dominantly of troctolite. Sulphide concentrations around 3-5% (typical of the disseminated sulphide type of PGE deposits, A1a, Table 3) appear to have been confined to some "disrupted" anorthosite layers.

GOODWIN LAKE - MALISEET MOUNTAIN:

There are two mafic-ultramafic bodies in the area. One of them is an elongated body extending from Goodwin Lake to Maliseet Mountain in a northwesterly direction. It underlies

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[1] Contribution to Canada-New Brunswick Mineral Development Agreement. Project carried by the Geological Survey of Canada.

TABLE 3

A TENTATIVE GENETIC CLASSIFICATION OF PLATINUM-GROUP ELEMENT DEPOSITS/OCCURRENCES

A) MAGMATIC

A1) Ni-Cu sulphide association

a) disseminated sulphide
Merensky Reef, Bushveld, South Africa
Bastard Reef, Bushveld, South Africa
Platreef, Bushveld, South Africa
J-M Reef, Stillwater, Montana
Picket Pin, Stillwater, Montana
Lac des Iles, Ontario

b) massive sulphide
Norils'k, USSR
Pechenga, USSR
Kambalda, Australia
Delta, Ungave, Quebec
Sunbury, Ontario
Gordon Lake, Ontario
Namew Lake, Manitoba
Muskox, Northwest Territories
Wellgreen, Yukon

A2) Chromite association

UG-2, Bushveld, South Africa
Bird River, Manitoba
Big Trout Lake, Ontario
alpine-type chromitites, China

A3) Ilmenite-magnetite association

apatite-rich titanomagnetite deposits (localities unknown), USSR

B) HYDROTHERMAL

Dreikop, Bushveld, South Africa
Unst ophiolite, Shetland, U.K.
New Rambler, Wyoming
Peter Lake, Saskatchewan
Nicholson Bay, Saskatchewan
Rathbun Lake, Ontario
Bravo, Ungava, Quebec

C) PLACER (derived mostly from Alaskan or zoned complexes and alpine-type ultramafic complexes)

Ural, USSR
Cordillera, British Columbia
Colombia
Ethiopia

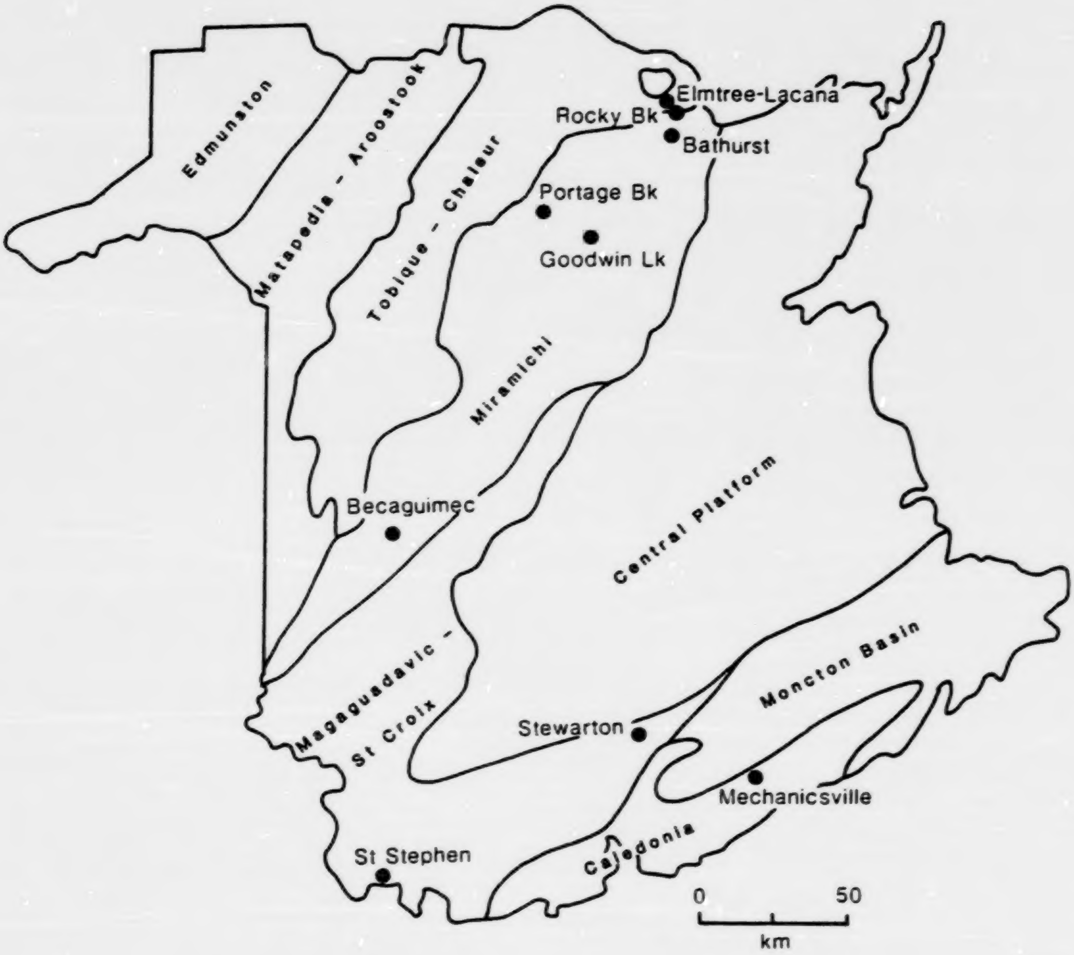

FIGURE 31. Location map showing distribution of mafic and ultramafic rocks with regard to tectonic zones of New Brunswick.

an area of approximately 2 km^2. The other one is located about 2 km northeast of Goodwin Lake. This is a small body underlying an area of only 0.5 km^2. Logging of the core from about 17 diamond-drill holes and sampling continued during the summer of 1987. On the basis of core logging and very limited mapping (due to extremely poor exposure), the bigger body consists predominantly of gabbronorite, norite, and gabbro whereas the small one is made up troctolite and peridotite. Sulphides are abundant and confined to noritic and peridotitic rocks. Sulphides occur as semi-massive to massive concentrations, as matrix to the cumulus minerals and in the pegmatitic segregations along with some hydrous phases.

MECHANICSVILLE:

The Mechanicsville intrusion is located approximately 20 km southwest of Sussex, in the Precambrian Coldbrook Group of volcanosedimentary rocks. It underlies an area of approximately 8 km^2. Reconnaissance mapping of the intrusion at 1:10 000 scale revealed that the intrusion is layered and consists of troctolite, picritic troctolite, olivine gabbro, peridotite, and pyroxenite units. Sulphide concentrations up to 4-5% were observed in some troctolitic and peridotitic rocks. Sulphides are interstitial in nature and erratically distributed. In many occurrences, chalcopyrite appears to be an abundant sulphide.

STEWARTON:

The Stewarton Complex is located approximately 20 km west of Sussex, in Silurian rocks. It is an elongate, northeast-trending body underlying an area of approximately 42 km^2. It consists mainly of gabbroic rocks (McCutcheon and Ruitenberg 1987). Some of the rocks display compositional layering. Some rocks with cumulus olivine and augite contain abundant magnetite and ilmenite up to 40%. The abundance and distribution of such rocks are not known yet.

ROCKY BROOK - MILLSTREAM:

Highly serpentinized ultramafic rocks occur along the Rocky Brook - Millstream Fault for a distance of approximately 9 km. The body appears to have a width of 100 m along the Stephens Brook valley. The body was studied and sampled on the scattered outcrops, mostly along Stephens Brook and in one diamond-drill hole. The rocks are strongly serpentinized and in places pervasively carbonatized. Several per cent of sulphides and chromite are present.

LACANA'S ELMTREE PROPERTY

A mafic body which hosts Au mineralization and an ultramafic body about 600 m to the north were studied and sampled. The mafic body is made up of cumulate and non-cumulate rocks comprising gabbronorite, gabbro, and anorthositic gabbro. Gold mineralization in the mafic body appears to have been controlled by steep-dipping east-west-trending structures. Detailed lithologic and structural mapping at 1:200 scale revealed that the major gold-bearing shear zones are brittle in character in the cumulate portions of the body. Shear zones in the ophitic portions of the body, on the other hand, are brittle to ductile in nature. Such shear zones apparently did not provide fluids a sufficient conduit, and consequently they are usually found to be barren. The ultramafic body is composed of strongly serpentinized and partially carbonatized dunite and peridotite. Structures with similar attitudes to those of the Au-bearing shear zones in the mafic body also carry some gold mineralization (Don Hoy, personal communication). Such structures are currently being explored for possible hydrothermal platinum-group-element mineralization.

BATHURST:

Abundant mafic intrusive rocks mapped as Ordovician rocks (Om) on the DNR 1/4 mile geology maps occur in the Tetagouche Group sedimentary and volcanic rocks. Field studies carried out on these mafic intrusions suggest that they are mostly subvolcanic sills which appear to be consanguineous with the mafic volcanics in the area. Although most of the intrusions are composed of noncumulate rocks, some contain plagioclase and plagioclase-augite cumulates. Most of these rocks carry minor amounts of sulphides.

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AEROMAGNETIC TOTAL FIELD, GRADIOMETER, VLF SURVEYS - NEW BRUNSWICK[1]

E. Ready and D. Teskey
Geological Survey of Canada
Ottawa, Ontario K1A 0E8

The index maps (Figures 32 and 33) show the location for the 1985-86 survey, released in 1987 and the 1986-87 survey to be released in late 1987. In both cases flight-line separation was 300 m at 150 m above ground. VLF-EM data have also been recorded using stations at Cutler, Maine and Annapolis, Maryland. The vertical gradient and total field data are presented as 1:20 000 contour maps and as 1:50 000 colour interval maps. The VLF quadrature data are plotted as stacked profiles on the back of the vertical gradient colour maps so that they may be viewed concurrently with the gradiometer data using a light table. The zero contour of the vertical gradient has been shown to outline very closely contacts between rock masses with contrasting magnetization such as volcanics and sedimentary units, whereas VLF data have proven to be useful for the delineation of near-surface conductors and zones of contrasting conductivity. These two surveys essentially complete the gradiometer-VLF mapping of the northern part of the Miramichi volcanic-sedimentary belt.

Figure 34 shows the index map for a new aeromagnetic, total field, gradiometer, VLF survey for which the contract has been let in the fall of 1987 in the Avalon belt of southern New Brunswick.

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[1] Contribution to Canada-New Brunswick Mineral Development Agreement. Project carried by the Geological Survey of Canada.

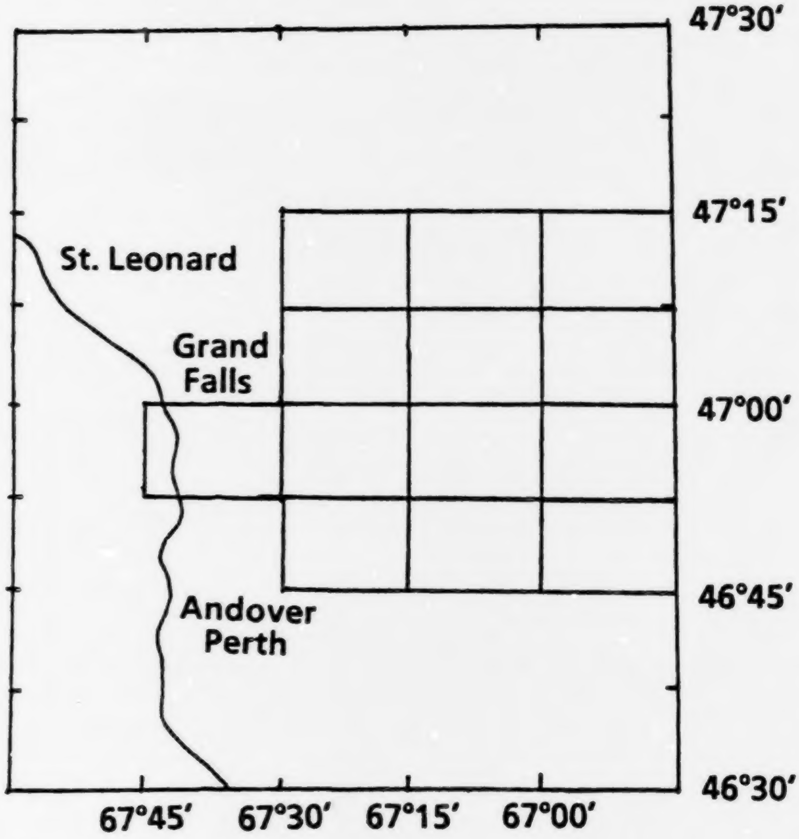

FIGURE 32. Location map for New Brunswick Aeromagnetic, Gradiometer Survey, 1985-86.

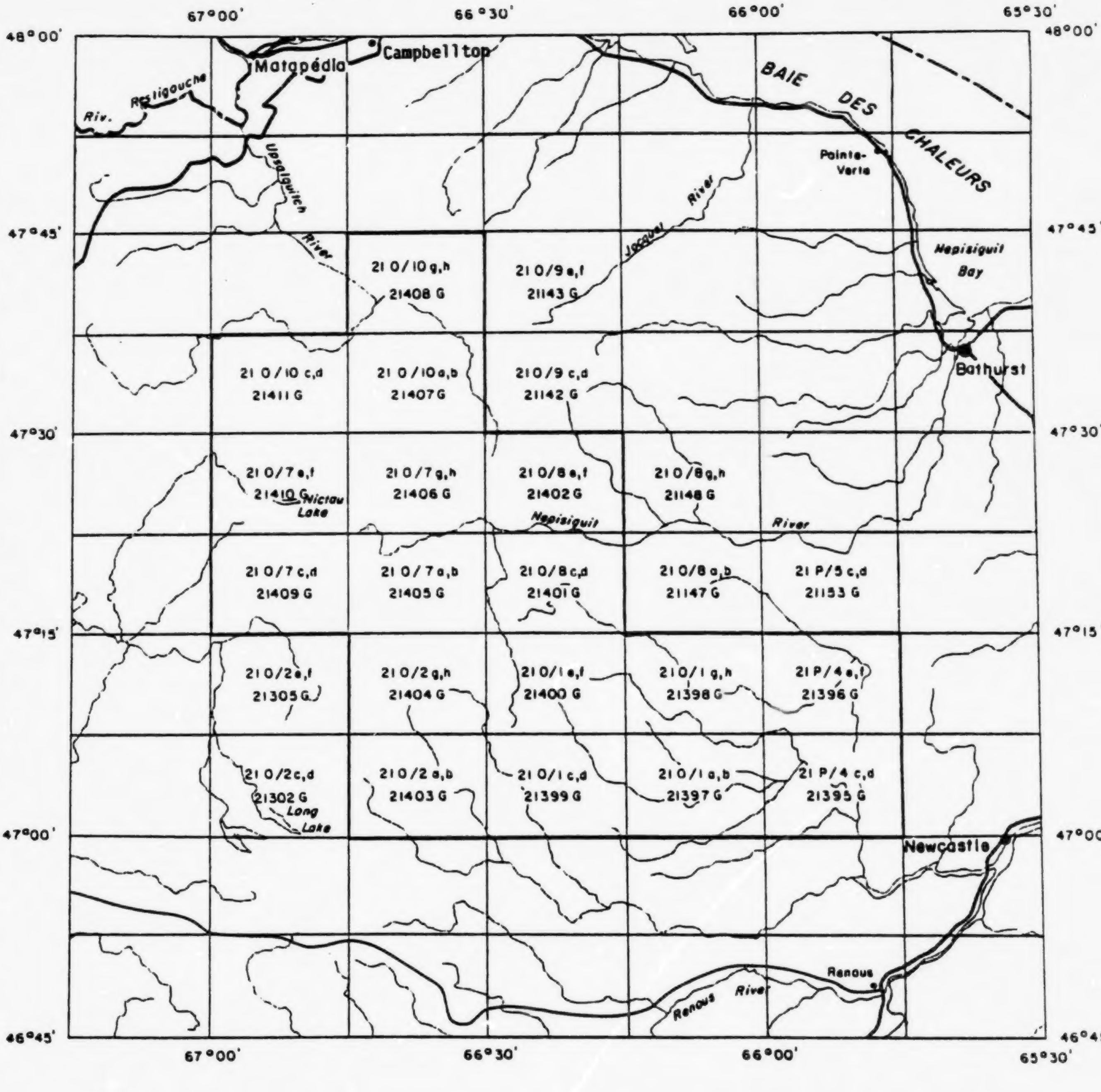

FIGURE 33. Index map - New Brunswick Aeromagnetic, Gradiometer Survey, 1986-87.

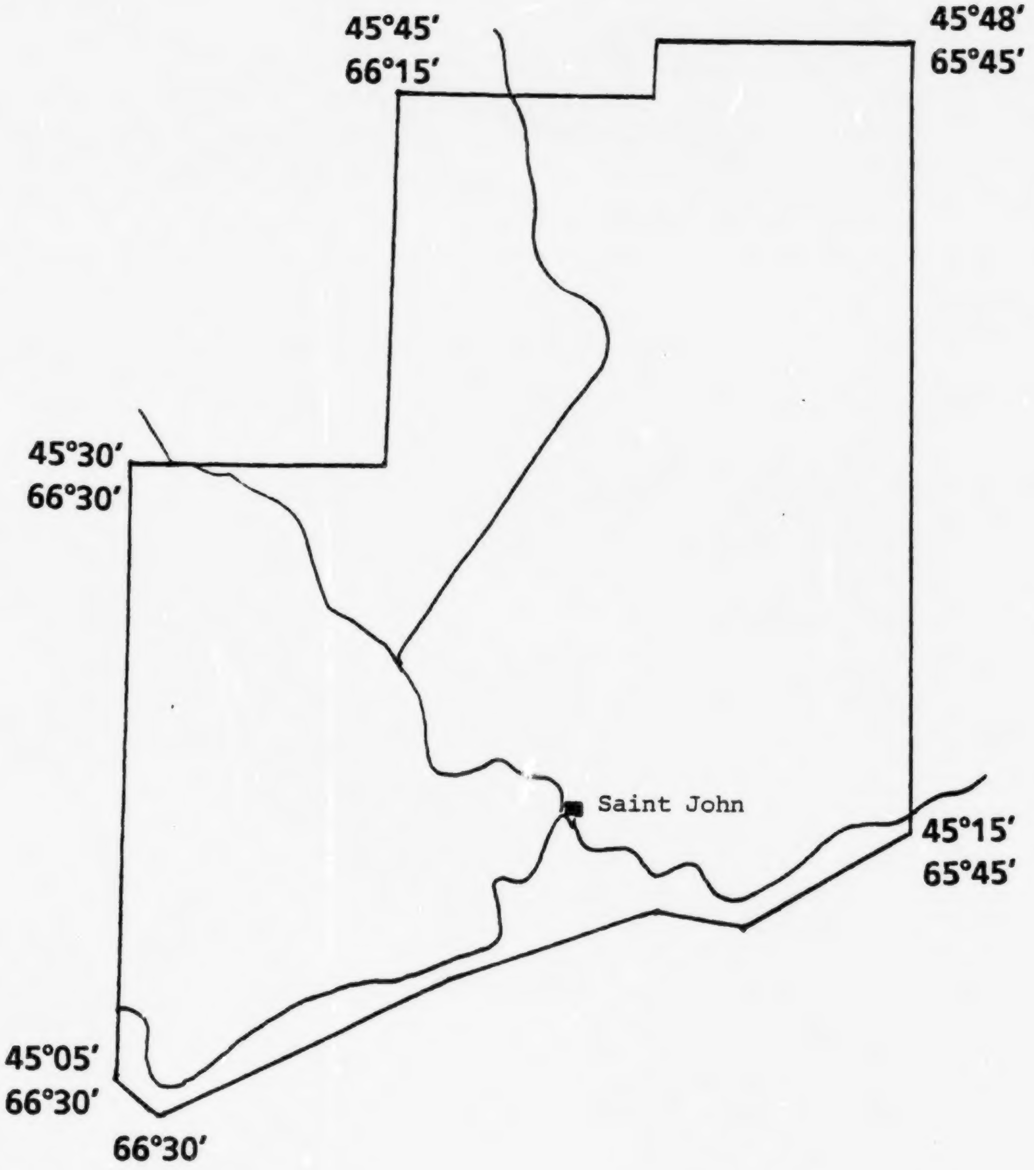

FIGURE 34. Location map - New Brunswick Aeromagnetic, Gradiometer Survey, 1987-88.

MINERALOGICAL AND THERMAL ZONING IN THE WOODSTOCK MINERAL DISTRICT, NEW BRUNSWICK[1]

Kirk Stevens, Montreal, Quebec

INTRODUCTION

The Woodstock mineral district contains about thirty-five individual base- and precious-metal prospects within a 150 km^2 north-south-trending belt (Figure 35). Copper is the most common economic commodity with locally abundant concentrations of Pb and Zn. A few prospects contain concentrations of up to approximately 1 g/t Au. Generally, the prospects are localized in or near Devonian granitic bodies which intrude Cambro-Ordovician quartzites and slates. The geology of the Woodstock district, with emphasis on the mineralized showings is described in Thomas and Gleeson (1986; 1987).

The principal aim of the present investigation is to define regional variations in vein mineral assemblages and fluid inclusion homogenization and melting temperatures in vein quartz. Such variations could permit determination of the number and extent of hydrothermal systems associated with vein formation in the Woodstock district. Relating known mineral occurrences to regional hydrothermal systems may result in the refinement of exploration guidelines on both district and local scales. A second objective of the project is to determine sequential and genetic relations between different mineralization and/or alteration events at selected sites with the aid of petrographic and fluid-inclusion studies.

OBJECTIVES

Suites of rock samples from deposits and occurrences within the study area and field data required for this investigation were collected under a previous MDA contract-Metallogeny of the Woodstock area, conducted for the GSC (Thomas and Gleeson 1987). Work completed to date comprises 1) a reconnaissance survey of fluid inclusions in vein quartz and altered intrusive rock samples from sites throughout the district; 2) detailed mapping of zoning patterns in vein mineral assemblages and fluid inclusion homogenization and melting temperatures in vein quartz from the north Gibson Stock area, Figure 35; and 3) comparison of fluid inclusion homogenization and melting temperature data from intrusive rock quartz phenocrysts with different quartz vein types from the north Gibson stock area.

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[1] Contribution to Canada-New Brunswick Mineral Development Agreement. Project carried by the Geological Survey of Canada.

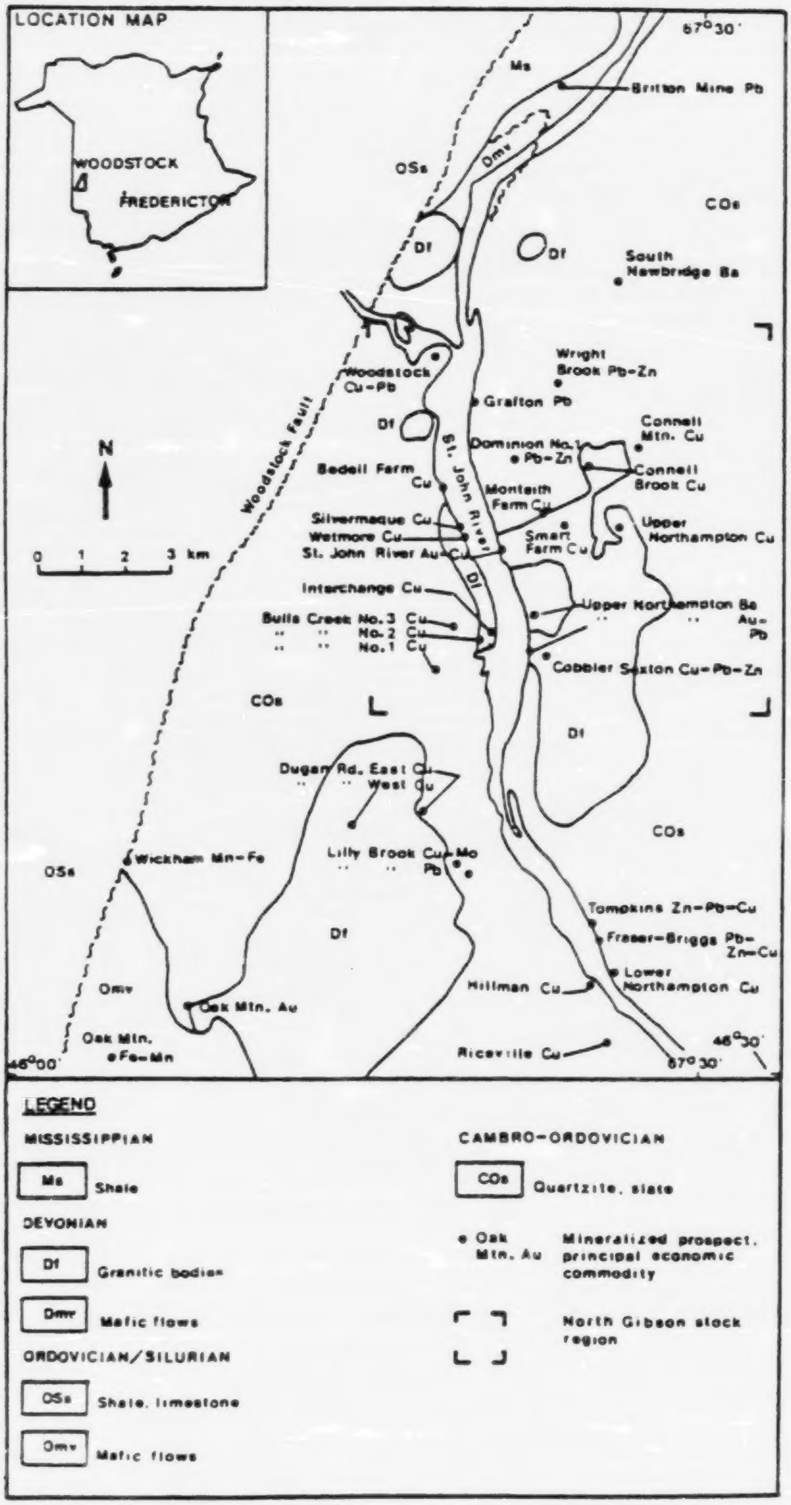

FIGURE 35. General geology and locations of mineralized prospects in Woodstock district, New Brunswick (after Thomas and Gleeson 1987).

PRELIMINARY RESULTS

The fluid inclusion reconnaissance survey indicates that simple two-phase (vapour-liquid) fluid inclusions are the predominant inclusion type. Paragenetic studies of inclusions with different vapour:liquid ratios indicate that there were at least two major hydrothermal events in the Woodstock district: a widespread, relatively low temperature event and a higher temperature event which occurred only in some parts of the district. Mineral occurrences at which higher temperature fluids were most common (based on variations in the relative abundances of fluid inclusions with large vapour:liquid ratios) are Riceville Cu, Oak Mountain Au, and Fe-Mn prospects in the south part of the study area; and Connell Mountain Cu, Bulls Creek Cu, and Upper Northampton Au occurrences in the north Gibson stock area.

Vein mineral assemblage mapping in the north Gibson stock area shows that veins containing quartz and/or Cu-Fe- and/or Fe-sulphide minerals occur throughout. They are most abundant in a narrow belt trending about 045° which runs between Connell Mountain and Bulls Creek. Carbonate mineral-, galena-, or sphalerite-bearing veins are localized north and south of the west end of this belt. Average vein quartz fluid inclusion homogenization temperatures are 150 to 200°C in most samples. Some samples from a few sites have average homogenization temperatures greater than 210 to 220°C. Vein quartz fluid inclusion salinities range from 2 to 9 equivalent weight per cent NaCl and are lower in the northwest than in the southeast parts of the north Gibson stock area. Less than 10 weight per cent CO_2 is present locally in vein quartz fluid inclusions throughout the north Gibson stock area.

Variations in homogenization temperatures and fluid composition of inclusions associated with pervasive alteration and mineralization in intrusive rocks and those associated with mineral deposition in different vein types are complex. Trends that are emerging are: 1) fluid temperatures varied from relatively high to relatively low during pervasive alteration and mineralization of intrusive rocks and deposition of quartz + Cu-Fe or Fe-sulphide veins, whereas fluid temperatures were relatively low during deposition of carbonate mineral-, galena-, or sphalerite-bearing veins, and 2) CO_2 was more abundant in vein quartz fluid inclusions than in intrusive rock fluid inclusions.

The vein mineral zoning trends described above for the north Gibson stock area, the local but widespread presence of CO_2 in vein quartz fluid inclusions in this region, and similar vein quartz homogenization and melting temperatures throughout this area, suggest strongly that the veins were deposited by a single hydrothermal system in which fluid temperature and composition evolved with time. Homogenization temperatures from intrusive rock-hosted veins were generally lower than 250° C and indicate that these parts of the igneous intrusions had cooled to well below their solidus temperatures prior to vein deposition. The heat sources for the north Gibson stock area were probably deep-seated portions of the presently exposed stock.

The regional distribution of mineralization grades in the Gibson stock area has not yet been evaluated in detail in the context of regional zoning patterns described above. However, the Connell Mountain porphyry-copper prospect, which contains the highest grade of the Woodstock-area showings, is the site at which the highest recorded vein quartz fluid inclusion average homogenization temperatures occur. In view of the probable deep-seated heat sources for mineralizing fluids in the north Gibson stock area, local high-temperature fluid pulses can be reasonably hypothesized to have been channeled toward zones of highest fracture permeability between the heat sources and the present surface. High fracture permeability is required for formation of economic mineral deposits; thermal "hot spots" are therefore favourable places in which to conduct mineral exploration.

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VOLCANISM OF THE EASTERN PORTION OF THE DEVONIAN VOLCANIC BELT OF PASSAMAQUODDY BAY, SOUTHWESTERN NEW BRUNSWICK: A PROGRESS REPORT[1]

Van Wagoner, Nancy A., McNeil, Wayne, and Thick, Mike
Department of Geology
Acadia University
Wolfville, Nova Scotia B0P 1X0

An east-west trending belt of Devonian volcanic and sedimentary rocks covering an area of about 125 km^2 is exposed along the coast of Passamaquoddy Bay, southwestern New Brunswick (Figure 36). This sequence was correlated with the Early Devonian (Gedinnian) Eastport Formation of Maine, and it was proposed that the New Brunswick rocks also be termed Eastport (Pickerill and Pajari 1976). The sequence is gently tilted and faulted, but generally youngs to the west. Previous mapping (Hay 1967; Fay 1987; and Whaley 1981) indicates that the eastern portion of the belt comprises a bimodal sequence of mafic and felsic rocks, whereas, the western portion is primarily mafic and intermediate volcanic rocks.

During the summer of 1987 the detailed mapping at a scale of 1:10 000 of the older bimodal sequence, which began in 1984, was completed (Van Wagoner 1984; 1986) (Figure 36). The area was divided into 46 mappable lithologic units, for the purpose of determining the volcanic stratigraphy (history), tectonic setting, and geochemistry of the area.

The map area comprises interbedded rhyolitic and basaltic flows and pyroclastic rocks, and red and green-gray shale and sandstone. Rhyolitic rocks are volumetrically most important and intermediate rocks are mostly intrusions. The sequence is biomodal and subalkaline. The rocks are gently tilted, cut by numerous faults, and display a consistent east-west cleavage.

Hawaiian, Strombolian, Plinian, and Vulcanian eruptive styles are represented. The mafic units form flow, scoria cone, phreatomagmatic tuff cone, and peperitic breccia deposits. The felsic units were emplaced as welded and nonwelded airfall, ash cloud and ground surge, and pyroclastic flow deposits, and rarely as lava flows. There is evidence for several small volcanic centres. Upper levels of a volcanic belt are indicated by the paucity of reworked volcanic deposits, abundance of rhyolitic welded pyroclastic flows and coarseness of the tuff

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[1] This work was funded by a contract from the Geological Survey of Canada as part of the Canada-New Brunswick Mineral Development Agreement, and an NSERC operating grant to N. Van Wagoner.

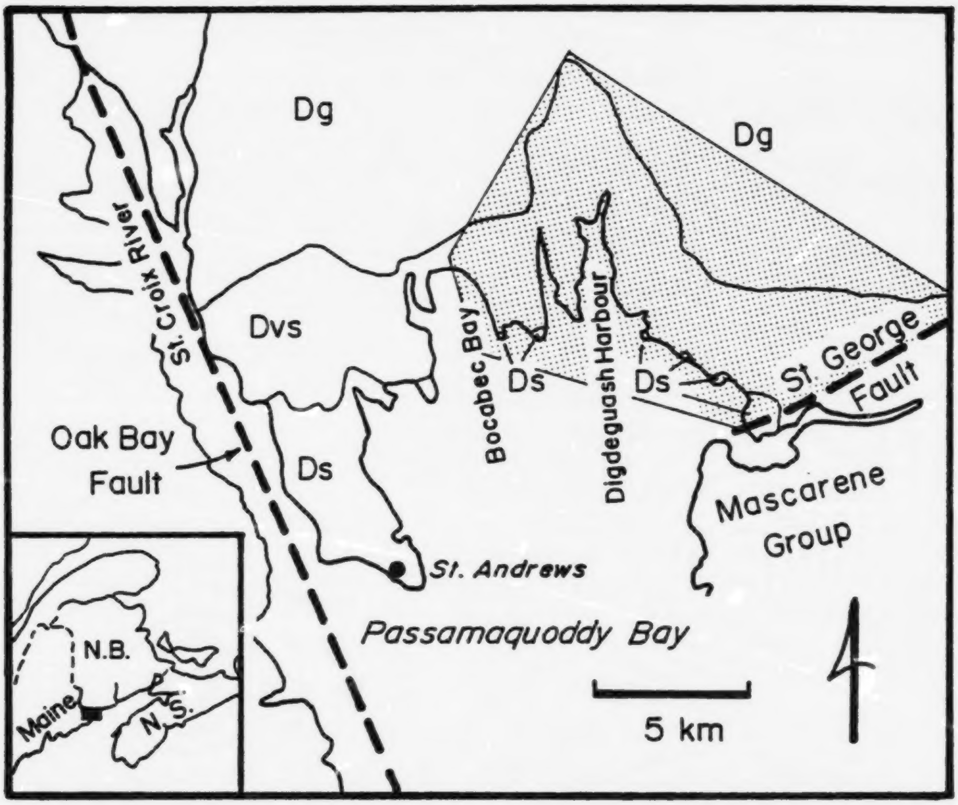

FIGURE 36. Index map of the study area showing the general geology after Pickerill and Pajari (1976) and Ruitenberg and McCutcheon (1980). Shaded area indicates the portion of the volcanic belt mapped in detail. Dg = Devonian granitoid rocks, Dvs = Devonian volcanic and sedimentary rocks, Ds = undifferentiated Silurian and Devonian rocks.

breccias. Periods of volcanic quiescence are marked by beds of siltstone and sandstone. Sedimentation changes from littoral to fluvial upward in the section, indicating that volcanism was subaerial, but near sea level near the base of the section, with elevation increasing upward. The most extensive alteration and sulphide mineralization is primarily associated with mafic peperitic breccias deposited near sea level and mafic intrusions.

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REGIONAL METALLOGENIC STUDIES, CHALEUR BAY BELT, NEW BRUNSWICK[1]

Gordon P. Watson
Geological Survey of Canada
Ottawa, Ontario K1A 0E8

Most of the field work for this project initiated in 1985 has now been completed. This year regional lithochemical studies continued with more than 80 new locations examined and sampled in areas from Millville to Hartland, near New Denmark, and particularly in the vicinity of Gulquac River, Sadler Mountain, and Mt. Costigan. Approximately one-quarter of this year's field season was spent mapping and sampling rocks of the Costigan Mountain formation (St. Peter 1978; 1982) to better understand the regional geologic context of mineralization at Mt. Costigan. More detailed field investigations of the Mt. Costigan Pb-Zn deposit including trench mapping at 1:50 scale, drill-core logging and sampling were conducted at the same time by N.D. Cox of the University of Ottawa as part of an MSc thesis study. The field studies will be augmented by further laboratory work this winter with a summary report being produced next spring.

Over 500 mineralized and non-mineralized rock samples have been collected from Silurian and Devonian rocks along the length of the Chaleur Bay Belt. Sample-location maps and a preliminary analysis of the regional geochemistry of volcanic rocks will be displayed at this forum.

The Elmtree gold property of Lacana Mining Corp., situated some 30 km northwest of Bathurst, has been the focus of a more detailed subproject initiated last fall. This year, R. Millar, a BSc student from the University of Waterloo, conducted an XRD and microprobe study of alteration minerals associated with mineralization. Preliminary results of this work show the non-metallic alteration mineral assemblage in the West Gabbro Zone to include quartz+chlorite+albite+sericite+carbonate minerals+(talc). Metallic minerals identified include, in addition to native Au, arsenopyrite, chalcopyrite, pyrrhotite, galena, and sphalerite with small amounts of jamesonite, boulangerite, stannite, and cassiterite. The latter four phases had not been previously documented at this deposit and were first identified by D.C. Harris of the Mineralogy and Chemistry Subdivision of the GSC.

Continuing assessment of the application of remote sensing to metallogeny in northern New Brunswick involved testing the use of vegetation sampling to detect mineralization. In June, some 500 leaf and needle specimens from 5 varieties of deciduous and coniferous trees were collected over the known mineralization on the Elmtree property and from a surrounding 30 x 30 km area. The abundances of a variety of trace elements including Au, Hg, As, and Mo in these samples were analysed. Anomalous concentrations for each of these elements were found in samples of sugar maple and balsam fir over the two known auriferous zones on the Elmtree property. The highest value obtained for Au was 68.9 ppb in balsam fir with background abundances around 0.1 to 0.2 ppb. The biogeochemical anomalies coincided with those obtained by conventional soil-sample surveys previously conducted by the company. Further, there is a detectable spectral anomaly in LANDSAT TM data for bands 4, 5, and 7 over the property in comparison to surrounding areas of similar forest type. This could reasonably be attributed to differences in reflectance caused by metal stressing of the vegetation.

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[1] Contribution to Canada-New Brunswick Mineral Development Agreement. Project carried by the Geological Survey of Canada.

Various types of geoscience data generated by this project, other ERDA projects involving airborne geophysical surveys, provincial mapping, and lithochemical sampling projects and earlier geochemical surveys have been compiled in digital form. These multiple data sets are being analysed in conjunction with the remotely-sensed data from LANDSAT imagery with an image-analysis system recently acquired by the Mathematical Applications group of the GSC. This facility will allow us to identify and then search for coincident anomalous features related to the location of mineral occurrences and provides a tool for a truly multi-disciplinary approach to metallogeny in New Brunswick.

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FIELD, GEOCHEMICAL, AND ISOTOPIC STUDIES OF GRANITIC ROCKS IN NEW BRUNSWICK[1]

J.B. Whalen and M.L. Bevier
Geological Survey of Canada
Ottawa, Ontario

This project, which was initiated in 1985, involves: (1) a detailed petrographic and geochemical study, including trace elements of economic interest (e.g., Sn, W, Mo, Ta, U, Th, Cu, Pb, Zn, Au, REE), of 326 representative samples of the Paleozoic granites from all the tectonostratigraphic terranes in New Brunswick (Figure 37); (2) common Pb (98 samples), U-Pb zircon (25 samples), and Rb-Sr and K-Ar muscovite and biotite (26 samples) isotopic analyses of the granitic rocks; and (3) detailed geological mapping (1:50 000 scale) at the northern end of the Central Pultonic Belt; coverage includes the undeformed Mt. Elizabeth intrusive suite and portions of the North Pole Stream Granite in addition to the deformed granites in this region (Whalen 1987). This work will provide data important for petrologic, tectonic, and metallogenic models in the New Brunswick Appalachians.

Comparison of modal data for New Brunswick granites and Australian I-, S-, and A-type granites (Figure 38) indicates that most samples resemble I- and A-type granites. Some Miramichi terrane granites which plot in the S-type granite field are definitely of S-type, for they are muscovite-cordierite-bearing. Though there are unambiguous A-type granites present in New Brunswick (e.g., Mt. Elizabeth alkali granite and the Welsford complex), others which plot in the A-type field in Figure 38 may be transitional between A- and I-type granites (e.g., Burnthill suite and Saint George Batholith). Within Elmtree terrane, the proportions of mafic to felsic composition intrusive rocks are approximately equal, whereas in the other terranes, felsic compositions vastly predominate (greater than 80% by volume). Based on field evidence, some of the intermediate compositions present in both Miramichi and St. Croix terranes result from maga mixing between mafic and felsic compositions.

Deformed granites and relatively undeformed granites of Miramichi zone, based on field evidence and previously published Rb-Sr, K-Ar and Ar-Ar ages (Fyffe et al. 1981; MacLellan et al. 1986), have generally been considered to be of Ordovician and Early to Middle Devonian age, respectively. The gneissic granites contain metamorphic muscovite and garnet, are very felsic (SiO_2 average and range = 73.4 (66.2-78.5)) (Figure 38),

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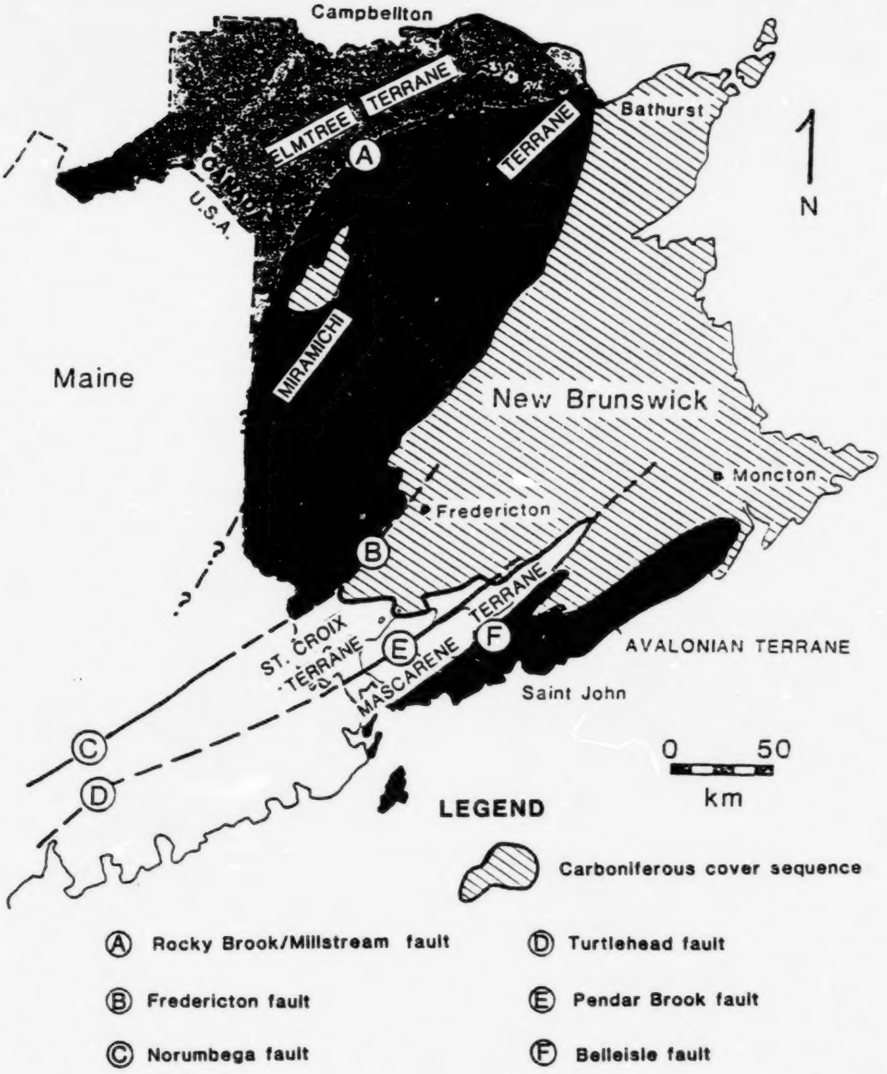
[1] Contribution to Canada-New Brunswick Mineral Development Agreement. Project carried by the Geological Survey of Canada.



TECTONOSTRATIGRAPHIC TERRANES

after Fyffe and Fricker (1987)

FIGURE 37. Location map showing New Brunswick tectonostratigraphic terrane boundaries and designations.

and have relatively high molecular Al_2O_3/ $(CaO+K_2O+Na_2O)$ values (average and range = 1.04 (0.93-1.20). Though these features suggest derivation from continental crustal source rocks, only a few samples have S-type granite characteristics (Figure 38). Zircon dating and preliminary examination of geochemical data substantiate the suggestion of Whalen (1987) and van Staal (1987) that these plutons are consanguineous with felsic volcanics of the Tetagouche Group.

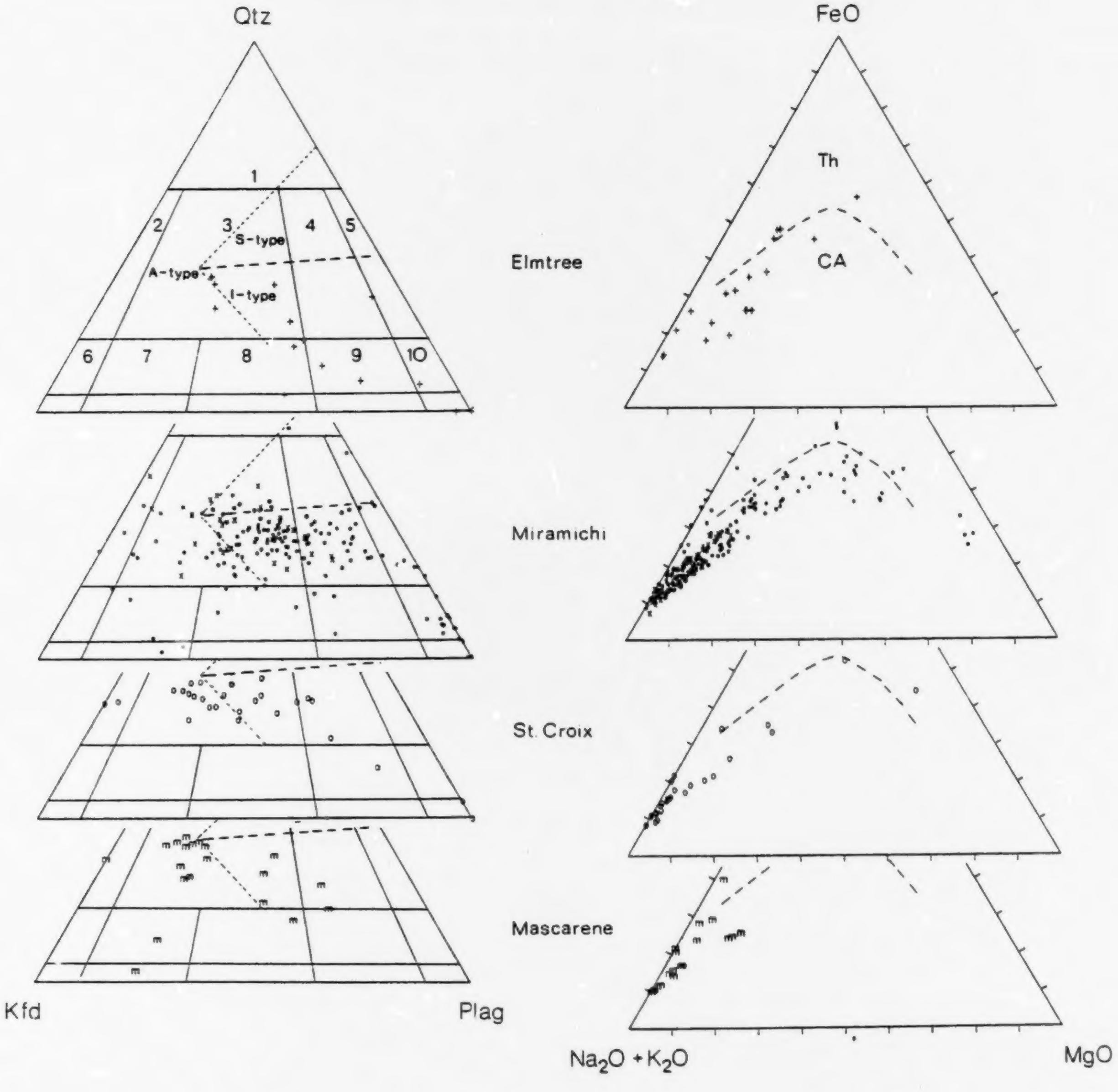


FIGURE 38. Quartz-plagioclase-K-feldspar modal plots and AFM diagrams for New Brunswick granites of various tectonostratigraphic terranes (see Figure 37). Granites of Miramichi terrane have been subdivided into deformed (X) and undeformed (*) plutons. Modal classification fields after Streckeisen (1973):

1. quartz-rich granite
2. alkali-feldspar granite
3. granite
4. granodiorite
5. tonalite
6. alkali-feldspar quartz syenite
7. quartz syenite
8. quartz monzonite
9. quartz monzodiorite
10. quartz diorite/quartz gabbro

(caption continued on next page)

Also shown on Figure 38 are fields for I-, S-, and A-type granites of the Lachlan fold belt, S.E. Australia from Bowden et al. (1984). The shaded region between I and S fields is a region of overlap. Modal data from point counts of 1000 points on 16 x 12 cm stained rock slabs. AFM dividing line between calc-alkaline (CA) and tholeiitic (Th) fields from Irvine and Barager (1971).

U-Pb systematics for zircon from granites in Miramichi terrane reflect significant inheritance of radiogenic Pb from xenocrystic zircon and, in some cases, Pb loss (probably due to more recent weathering and alteration). Though no concordant U-Pb zircon ages have been obtained, the new data of this study (Table 4) do provide additional constraints on the timing of plutonism in this terrane. The greater two sigma errors in the plus direction are a consequence of inheritance in the zircons.

TABLE 4

PRELIMINARY U-Pb ZIRCON AGES FOR MIRAMICHI GRANITES

Name	U-Pb Age (Ma)
DEFORMED PLUTONS:	
Fox Ridge	452 +15/-1
Meridian Brook	464 +43/-10
Mullin Stream Lake	458 +16/-1
Serpentine River	455 +12/-9
South Renous	448 + 17/-16
Trousers Lake	434 +29/-6
UNDEFORMED PLUTON:	
Mt. Elizabeth alkali granite	414 +11/-1

Analytical techniques detailed in Parrish et al. (1987).
Quoted errors are 2 sigma.

Five deformed granites of Miramichi terrane give Middle to Late Ordovician U-Pb zircon ages (448-464 Ma) and show evidence for an inherited component. The presence of a xenocrystic zircon component in these granites is compatible with their derivation from older continental crust at depth. Calculated upper intercepts with concordia range from 1.2 to 2.7 Ga. No geological significance should be attached to specific upper intercept ages, however, as they probably represent an average age for xenocrystic zircon of a variety of ages.

A new U-Pb zircon age for the alkali granite phase of the Mount Elizabeth intrusive suite (Table 4) indicates that the "Devonian" undeformed granites of Miramichi terrane include plutons of Silurian age. The presence of Silurian plutonism in areas of the Canadian Appalachians where only Devonian igneous activity had been thought to have occurred was suggested and confirmed by Currie et al. (1986) and Whalen et al. (1987).

Initial Pb isotopic ratios from Miramichi granites of all ages also indicate an old, upper crustal Pb component in the source area for these plutonic bodies (Bevier 1987). This Precambrian component has a range of Pb isotopic compositions somewhat similar to the range displayed by Precambrian granitic units from the Avalonian terrane in southern New Brunswick, raising the possibility that Avalonian basement is much more extensive in the substrate than previously supposed. The existence of a pre-Ordovician upper crustal continental basement to the Miramichi terrane helps constrain viable tectonic models for generation of the middle Paleozoic igneous rocks to continental settings, i.e., a back-arc basin or intra-continental rift, as suggested by van Staal (1987).

To the north of Miramichi terrane, Devonian granitoids within the Elmtree terrane have fundamentally different, less radiogenic Pb isotopic compositions than Miramichi granites. This indicates that Elmtree terrane does not contain Avalonian basement and the boundary between Miramichi and Elmtree terranes is a fundamental crustal break. Devonian granitoids of the Mascarene and St. Croix terrane had an upper crustal source which isotopically only partially resembles Avalonian basement.

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UNIVERSITY OF NEW BRUNSWICK

REPORT OF ACTIVITY
DEPARTMENT OF GEOLOGY AND GEOLOGICAL ENGINEERING PROGRAM
UNIVERSITY OF NEW BRUNSWICK

H.W. van de Poll

GENERAL

The Department comprises 15 full-time faculty, 3 Post-doctoral Fellows, 2 Research Associates, 1 Professor Emeritus, 7 technical staff, and 3 secretarial staff, 13 PhD and 9 MSc resident and 5 non-resident post-graduate students, (seven of whom are working on N.B. projects), 60 undergraduate students (21 science majors in geology and 39 geological engineers). The NSERC supported the Department's research in the amount of $211 714 for the year and the MPHEC provided $63 707 for research equipment and $10 250 for building renovations during 1986-87. Research contracts for varying periods were negotiated; the Heath Steele Mine project (supported by funds and services from DNR&E, EMR, and the Noranda Group of companies in the amount of $292 000 for the current year) is renewable for three years, various projects with EMR in the amount of $188 298 and smaller amounts from the UNB Research Fund, Chevron, and others.

Twelve geologists and fourteen geological engineers graduated from UNB since our last report. Like last year this graduating class was noted for the number of honours, Dean's listings, and prizes awarded to its members. One of the geological engineers won an NSERC post-graduate scholarship. All of the graduates were employed for at least the summer. Three persons completed their MSc and one PhD was awarded during the past year.

Members of the faculty and graduate students published approximately 40 scientific papers and abstracts.

During the past academic year, the Department of Geology suffered two tragic losses by the sudden and unexpected deaths of Dr. W.E. Hale on September 23, 1986 and PhD graduate student, Ruixiang Gao on July 10, 1987.

Dr. W.E. Hale was a long-time member of our Department who, among his many accomplishments, was perhaps best known for his expertise in Third-World mineral development through his work with the UNESCO and CIDA. In addition to his many academic interests, Dr. Hale was the driving force behind the recently implemented Geological Engineering Program. He was an outstanding teacher, noted for his devotion to the betterment of his students. Many of his former students will remember Dr. Hale for his continued interest in their post-university careers. Those of us who have had the privilege to have been his student, colleague, or friend will miss his wit and quiet humour, his support, wisdom and council.

Mr. Ruixiang Gao came to us from China, first as a visiting scholar and subsequently as a post-graduate student. He had recently submitted his MSc thesis and he had begun his PhD field studies on 'Microstructures of Late Paleozoic Faults in Northern Nova Scotia' (under a GSC contract and supervision of Dr. P.F. Williams) when the tragic pedestrian-train accident occurred.

Drs. P.F. Williams, K.B.S. Burke, and H.W. van de Poll have returned from their sabbaticals respectively in Australia, China, Japan, New Zealand, Europe, and the U.S.A.; in Spain and England; and in Canada and England. Sabbatical vacancies were filled by Dr. C. Hy, Post-Doctorate Fellow and graduate of The University of Paris, who assumed some of Dr. Williams academic responsibilities and Mr. J. Chandra, who lectured in Geophysics during Dr. Burke's absence.

Following the death of Dr. W.E. Hale, who had just taken over the Chairmanship of the Department, Dr. J.P.A. Noble took over as Acting Chairman while the Department was in the process of selecting a replacement for this position. This vacancy has now been filled by Dr. H.W. van de Poll's acceptance of a three-year term as Chairman which commenced July 1, 1987. Dr. J.P.A. Noble is presently on a well-deserved year sabbatical in England, France, and Spain; while Dr. J.C. White is currently on sabbatical in the U.S.A.

Dr. B.E. Broster, graduate of the Universities of Waterloo and Western Ontario, joined the Department in July as Director of the Geological Engineering Program. He brings with him his experience of teaching in the geological engineering program at the Universities of British Columbia and Windsor, in addition to his consulting experience in exploration and geotechnical engineering. Dr. Broster is the newly elected representative for the Atlantic Region and Vice-President of the Canadian Quaternary Association.

Dr. A.L. McAllister has as of September 1, 1987 officially completed his teaching duties at UNB. As Professor Emeritus, Dr. McAllister will continue to occupy his office at the Geology Department for the foreseeable future and make his presence felt in guest teaching, research, student advice, and liaison with government and industry.

ENGINEERING GEOLOGY

Dr. Broster's research has focused upon applications of glacial processes and products relative to engineering, environmental, and exploration activities. This year NSERC-funded research into glacially induced soft-sediment deformation in northern British Columbia commenced as part of a joint study with Dr. J.J. Clague of the GSC, Vancouver. It is anticipated that a new research programme will be initiated into glacial dispersion in selected areas of N.B.

GEOCHEMISTRY

Dr. N.J. Susak is continuing his studies of cobalt solvation and metal-transport mechanisms in hydrothermal solutions. These are initial studies that will eventually be extended to determine metal transport in cobalt-nickel-arsenide ore deposits. Spectrophotometric studies with PhD graduate student, Mr. Pan, of cobalt chloro-complexes and bromo-complexes are nearing completion. Chloride complexes are ubiquitous in hydrothermal ore deposits. Bromine complexes were investigated to determine the influence of bond strength on the stability of transition-metal complexes. A study of the dissolution kinetics of cobalt oxide has been completed. This project demonstrated the feasibility of using an in-line spectrophotometric monitor for dissolution kinetics studies and should provide a significant improvement over the classical batch-type studies. Work on the hydrothermal soluability of cobalt oxides is continuing.

GEOPHYSICS

Dr. K.B.S. Burke and Ms. S. Slauenwhite completed an investigation of the nineteenth-century seismicity in the south-western part of N.B. under contract with the Geophysics Division of the GSC. Seven previously unlisted events were found for the Passamaquoddy Bay region. Evidence was also found that warrants significant changes to present listings of earthquake locations, times and magnitudes in the Canadian Earthquake Epicentre File. Dr. Burke and Ms. R. Comeau have started a similar investigation of twentieth-century earthquakes in the Passamaquoddy Bay region, again under a GSC contract.

Mr. G. Allcott has completed his evaluation of the use of magnetic and VLF methods for mapping geological contacts at the Heath Steele Mine as part of an MDA project and is presently writing his MSc thesis. He found that it was possible to use detailed magnetic measurements to find the dip and strike of specific rocks units near to the surface and that pseudo-sections of VLF data defined the tuff/porphyry contact well. Massive-sulphide veins, in the order of 1 m thickness, also give a good VLF response, at least to a depth of 30 m.

MINERAL DEPOSITS

Economic geology activity, under the general supervision of Dr. A.L. McAllister, continued to focus mainly on Appalachian mineral deposits with emphasis on massive sulphides.

A study has been initiated at Brunswick No. 12 Mine to investigate the nature and distribution of gold and the possible correlation between gold concentrations and specific stratigraphic units, as well as any relationship to alteration zones, intrusions, and structures. This study, conducted by Mr. P.E. Olson under supervision of Drs. A.L. McAllister and D.J. Bachinski, has shown the presence of several small discontinuous lenses containing elevated gold values (0.05-0.06 oz./ton) in the stratigraphically upper portion of the host strata. Preliminary results suggest that there may be a relationship between copper content and the elevated gold values.

At Heath Steele Mines, a 3-year project, jointly sponsored by the Federal and Provincial governments, is in its second year under the direction of Dr. P.F. Williams. The object of this study is to provide a general assessment of the geological structures, define the distribution of stratigraphic layers, and ultimately, to use these data to locate additional ore reserves. A full-time coordinator, Mr. J. Torrance and Post-Doctorate Fellow, Dr. Jacob de Roo, have been appointed to the project which in 1987 involved one PhD student, Mr. C. Moreton, one MSc student doing geophysics, and three assistants. Trenching is currently underway by subcontractors.

Work is continuing on certain other massive-sulphide, gold, and tungsten deposits in the Atlantic Provinces.

Dr. D.J. Bachinski and Ms. K. Kettles have completed their work on the Turgeon Fe-Cu-Zn deposit in the Fournier Group. Their study has shown this deposit to be mainly a subsurface hydrothermal replacement body.

Other work on sulphide deposits within the Bathurst area has shown that sedimentary reworking of sulphides in the Louvicourt Deposit is indicated by the presence of sulphide clasts occurring within the original hanging-wall succession of this deposit. This work by Mr. C. Beaumont-Smith, under supervision by Dr. D.J. Bachinski, is financially supported by Noranda Ltd. Additional projects by Dr. Bachinski include studies on redbed copper and porphyry-copper deposits and a CIDA-sponsored program with graduate student, Mr. B. Yokart, on volcanic-associated mineral occurrences in Thailand.

Ms's. M. Chrzanowski and C.G. Elliott are continuing their investigation on a beryl occurrence near Zealand in central N.B. They have submitted a progress report to Shediac Bay Inc. outlining the general geological setting of this deposit.

Dr. P.F. Williams and a graduate student, Mr. W. Roberts, have commenced a study on the structure of the potash in the Dennison Mine at Sussex as an aid to an improved economic assessment of its potash potential.

Dr. H.W. van de Poll continues his interest in the economic geology of the Permo-Carboniferous of N.B., N.S., and P.E.I. with emphasis on the lithostratigraphy, sedimentology, physical diagenesis, and paleoclimatic evolution of coal basins and of the P.E.I. redbeds for an overall evaluation of their economic potential with respect to coal, copper, uranium, natural gas, and gravel.

Mr. R.J. Ryan, PhD candidate under supervision of Dr. H.W. van de Poll, is currently investigating stratigraphic, sedimentologic, paleoclimatic, and other basinal factors in the numerous small low-temperature sediment-hosted Cu-U-Pb-Ag occurrences of the Tatamagouche syncline area of N.S. His studies are currently centred on the hypothesis that the mineralized Upper Pennsylvanian-Lower Permian strata of the area represent the exposed segment of a much larger transition zone between the predominantly red (Permian age) and predominantly grey and red (Pennsylvanian age) sequences. It is thought that in this transition zone the Cu, U, Pb, Ag minerals have been locally concentrated around plant remains following post-depositional oxidation and leaching of these elements from what are now the overlying redbeds. Downward reddening, a process that could be likened to the migration of an oxidation front on a large scale, ahead of which the mineral occurrences are concentrated, could have taken place during Triassic times below the Alleghenian-Variscan unconformity.

Dr. J.P.A. Noble is continuing supervision of the MDA-sponsored project dealing with diagenesis of the Albert Formation with graduate student, Mr. Ali Chowdhury. He is also supervising a project on the Stoney Creek Oil and Gas Field emphasizing the stratigraphy, structure, and depositional history of the reservoir-sandstone units with research associate, Mr. S. Foley, and with Mr. C. St. Peter of the DNRE.

Dr. J.G. Spray has completed his studies on an Archaean greenstone-hosted Ni-Cu-Co deposit from the Furnas terrain of Brazil following field work there in 1984. This study placed particular emphasis on the characterization of the komatiite host rock despite its metamorphism to amphibolite facies. The Furnas ore body is one of the first major greenstone-hosted nickel sulphide deposits to be discovered in Brazil.

PALAEONTOLOGY

Dr. A. Logan is continuing actuopalaeontological studies of modern hard substrate communities in the Bay of Fundy with a view to ascertaining their value for palaeoecological reconstruction in the Mesozoic. He is also working on competitive interactions of hermatypic corals in Bermuda and their significance in terms of distribution and succession of similar species in Tertiary and Pleistocene reefs.

Dr. J.P.A. Noble and his PhD graduate students, Mr. G. Young and Mr. D.J. Lee, continue their studies on Palaeozoic fossil assemblages with emphasis on Silurian corals and stromatoporoids and the relation of the N.B. and Gaspé faunas to those of other circum-Atlantic areas. This study not only contributes to a better understanding of coral and stromatoporoid taxonomy and paleoecology; it also provides a means to a more accurate reconstruction of plate movements.

Dr. R.K. Pickerill is continuing work on the structure, composition, ecology, and evolution of Silurian brachiopod-dominated communities of Arisaig, N.S. As well, he is studying the structure, composition, and evolution of Ordovician marine benthic communities in Quebec with Dr. T.L. Harland and in Wales with Dr. P.J. Brenchley. He is collaborating with Dr. M. Wade of the Queensland Museum, Australia, in a study of Cambrian jellyfish from the Saint John area. He continues his extensive trace-fossil research in Spain, Portugal, Quebec, Nfld., N.B., Alaska, Oregon, southern California, and northern Greenland. Mr. D. Fillion, one of his PhD graduate students, is undertaking similar studies in Oregon and southern California.

PETROLOGY

Dr. T. Dunn, the Department's igneous petrologist, joined the Department in August, 1986. He and his graduate students are working on several projects including studies of volcanic terrains in Thailand with Ms. S. Intasopa; experimental determinations of the partitioning of REE with Ms. A. Marinou, and of group IIB, IVB, and VB transition metals between clinopyroxene and silicate melts. During the summer of 1987, Dr. Dunn completed construction of a new one-bar, high-temperature experimental laboratory which he and Ms. Marinou are using for the experimental trace-element partitioning studies. Dr. Dunn also spent most of August in the field in southwest Washington State where he completed the reconnaissance field work for a new project on the volcanic petrology of Mt. Adams (a 3744-metre quaternary andesitic volcano). That project will concentrate on the petrogenesis of the volcano with particular emphasis on both spatial and temporal compositional variation of eruptives.

Dr. J.G. Spray is continuing his investigations on metamorphism and melting in fault and shear zones. This is being carried out at both the field and experimental level. The field work has centred on studies of thrust-related metamorphism beneath tectonically transported fragments of oceanic lithosphere and on thrust zones in the Canadian Rocky Mountains. It is hoped to extend field studies to encompass some of the larger fault systems of New Brunswick. In addition, the igneous and metamorphic genesis of the Elmtree basic complex of northern New Brunswick is being researched as part of Ms. P. Flagler's MSc thesis. The experimental work has focused on the application of friction-welding apparatus to the study of frictional heat phenomena in rock. A new laboratory has been established in the Geology Department which is the first of its kind in the world. The equipment enables fault movement to be simulated in terms of velocity, load (stress),and duration. Different fault rocks can be produced by this process (e.g., gouge at low power and melt at high power). The experimental technique has considerable potential for providing insight into fault dynamics and the generation of earthquakes (e.g., J.G. Spray 1987, Journal of Structural

Geology, 9, pp. 49-60). It is planned that these studies will also lead to a greater understanding of fluid movements and consequent mineralization processes occurring in fault zones.

Dr. L.T. Trembath is studying crystallization of feldspar in synthetic and natural systems. This latter project is concerned with a comparison of microstructure in natural and experimentally produced compositionally equivalent crystalline material and is aimed at developing a better understanding of the crystallization and emplacement of granitoids. He is presently updating the JCPDS Powder Diffraction File to include the complete data set for inorganic and organic materials.

REGIONAL MAPPING PROJECTS

Several members of the Department continue to be active in regional studies; Mr. R.H. Grant is continuing with his studies of Variscan tectonics west of Saint John; Dr. R.K. Pickerill, i5 5ollaboration with Dr. K.L. Currie of the GSC, and Dr. D. Nance of the University of Ohio is involved in regional mapping in the Saint John area (N.B.). Prof. I.M. Patel is working on the Precambrian-Cambrian boundary in N.B. Dr. J.P.A. Noble is continuing his regional stratigraphic studies of the Siluro-Devonian of northern New Brunswick, while the Acadian cleavage in mainly Siluro-Devonian rocks in southwestern New Brunswick and adjacent Maine is being investigated by Dr. P. Stringer.

Graduate students of Dr. H.W. van de Poll are continuing sedimentological mapping and basin analysis of Carboniferous and Lower Permian strata in eastern Canada. Specific project areas at present are around Tatamagouche (N.S.) being investigated by Mr. R.J. Ryan, and in southwestern P.E.I. by Mr. C. Place.

Postgraduate students working under Dr. P.F. Williams' direction continue mapping in the Dunnage Zone around eastern Notre Dame Bay (Nfld.).

SEDIMENTOLOGY

Dr. J.P.A. Noble's stratigraphic sedimentological and diagenetic studies, as part of a Siluro-Devonian Appalachian-Basin project in northern New Brunswick and the Gaspé, are still in progress.

Professor I.M. Patel is continuing a study of the sedimentology of the early Lower Cambrian Ratcliffe Brook Formation in southeastern New Brunswick and is attempting correlation with similar sequences in parts of the northern Appalachians and Europe.

Dr. R.K. Pickerill, in addition to contributing sedimentological work to a regional study of the Saint John Group, is also continuing his extensive studies of Middle Ordovician sedimentation of the Trenton Group carbonates of Quebec.

In addition to the obvious sedimentological bias of their regional projects mentioned above, Dr. H.W. van de Poll and Prof. I.M. Patel are continuing specialized studies on physical diagenesis. These studies concentrate on post-depositional processes related to compaction of the sediments. Their findings suggest that many sedimentary features, including grain-matrix and clastic ratios and certain types of sedimentary structures are not the result of primary processes, but are caused by secondary processes of sedimentary remobilization during compaction. This work is ongoing in conjunction with Carboniferous Basin analysis and has potential implication with respect to facies analysis, paleoseismic interpretations, syndepositional tectonics, and petroleum reservoir studies.

STRUCTURAL GEOLOGY

Drs. K.B.S. Burke and P. Stringer have commenced an investigation of neotectonic features in southwestern New Brunswick under a research agreement with EMR. A Jurassic dyke has been traced across the St. Andrews Peninsula and Creighton, Holt, and Orr points using magnetometer traverses. Offsets of this dyke are shown to be associated with northwest-trending faults at some locations, although the dyke appears to cross the Oak Bay Fault without displacement. Northwest-trending fault zones and all known locations of glacial striae are being examined for evidence of post-glacial displacements.

Electron microscopy research carried out by Dr. J.C. White has included characterization in ZnP_2 of features that influence its electronic properties, as well as elucidation of deformation and exsolution phenomena in deep crustal feldspars. His examination with MSc student, Mr. W. Maitland, of microstructures and microchemistry of hanging-wall and foot-wall rocks in the Hemlo, Ontario gold deposit is nearing completion.

Dr. P.F. Williams and students are working on major faults in Atlantic Canada including the Dover Fault, Nfld. with Mr. A. Caron, faults in southern N.B. with Mr. A. Leger, the Chanceport-Lukes Arm Fault system in Nfld. with Dr. Janos Urai, and the Indian Islands Fault, Nfld. with Mr. B. LaFrance. The objective of these studies is to synthesize Acadian ductile- and brittle-faulting history as a basis of understanding its influence on Carboniferous sedimentation and emplacement of quartz and calcite veins, many of which are related to the faults. Other structural work in the Notre Dame Bay includes studies with Ms. C.G. Elliott on certain folds that have previously been interpreted as slump structures.

Dr. P.F. Williams is also continuing his research with Dr. D. Keppie and Mr. S.J. Hwang on the structural implications of shear zones in the Shelburne area, N.S. In addition, he supervises an MDA-funded agreement to investigate with Dr. C. Hy the geological history of gold-bearing veins in Nova Scotia, and a new GSC-funded project at Thompson Mine, Manitoba with Dr. C. van Staal and Mr. W. Bleeker. Dr. Williams is conducting computer simulation experiments on the development of folds during shear straining.

RESEARCH AND PRODUCTIVITY COUNCIL

REVIEW OF ACTIVITIES AT THE NEW BRUNSWICK RESEARCH AND PRODUCTIVITY COUNCIL RELATED TO THE MINERAL INDUSTRY

Staff of the Mineral Development and Processing Department

The New Brunswick Research and Productivity Council (RPC) is a contract research organization, whose activities reflect the industry base of the province. The Mineral Development and Processing Department is responsible for mineral resource-related and energy resource-related projects.

Three sections are responsible for mineral-related projects. During the past year, the mineralogists and petrologists with the Department have provided a variety of services to individuals, corporations, and governments involved with earth resources in New Brunswick. The facilities have been expanded again this year with equipment and computer software additions to the electron microprobe and automated image analysis system which was installed last year. The Department facilities include an electron microprobe interfaced with automated image analysis, petrographic and reflected light microscopes, x-ray diffractometer, x-ray fluorescence, inductively coupled argon plasma emissions spectrometer (ICP), atomic absorption spectrophotometer and wet chemical laboratories.

In addition to studies on geological materials, microprobe and SEM analyses were performed on various materials which were being studied by the Department of Engineering Materials. Chemical analysis by electron microprobe of metals, corrosion products and imaging of fractures surfaces, were made. These materials were from various industries throughout the Province (e.g., oil refinery, mine mills, electric power stations, and pulp and paper mills).

Geological materials studied included rock samples for petrographic analysis, gold-bearing samples from deposits throughout New Brunswick, potash ore and mill samples, aggregate, bricks and concrete samples, and antimony ore and mill products.

The mineralogy group is involved in two MDA projects in the Province. RPC has a contract with Supply and Services Canada to study the mineralogy and geochemistry of the N.B. potash deposits. The contract is administered by CANMET. RPC is a sub-contractor to ADI Limited who have undertaken a project entitled "Alkali Reactivity of Potential Aggregate Sources in New Brunswick".

The mineralogy section has undertaken several studies for BMS. A comprehensive study was undertaken on the silver distribution in the copper circuit and copper, bulk, lead, and zinc concentrates and final tails from the BMS Concentrator. Approximately 500 grains of tetrahedrite, and equal number of galena grains, along with numerous bournonite and boulangerite grains were assayed for silver and antimony (antimony minerals) and sized by AIA-EPMA. An overall silver balance amongst the various mineral contributors was then established.

A metal distribution study by AIA-EPMA was completed on samples from the BMS Cu-Pb circuit as part of an "Electrochemical Parameter Study" for McGill University.

A complete sampling campaign of the BMS Concentrator was carried out in March 1987. The Samples will be studied to determine the distribution of free and unliberated sphalerite, galena, chalcopyrite, and pyrite. Selected samples will be studied to determine the behavior of the silver-carrier minerals. CANMET has been subcontracted to complete a mass balance of the BMS Concentrator.

Several ore-microscopy studies supported by AIA-EPMA were carried out on gold ores and concentrates to determine the nature of the gold mineralogy. The microprobe was also used to assist in determining the nature of silver in various products from the ERS pilot plant facility in Chatham, N.B. Many additional smaller mineralogical studies were performed in support of the mining industry.

The Industrial Chemistry and Analytical Services Section carried out a number of minerals-related projects. Approximately 100 samples of Albert County oil shale were analysed as part of a detailed delineation of the deposit. The data obtained revealed that areas of relatively high kerogen concentration were present. As part of a continuing project to characterize certain provincial soils, approximately 200 samples were subject to size fractionation (pipette) analysis and determination of pH.

A study on the acid-generating potential of waste rock from a complex base-metal sulphide deposit was undertaken.

The Processing Section has been heavily occupied with the completion of the Sulphation Roast Leach Pilot Plant project. A technical report and an engineering and economic study were completed. Final clean-up of the Enhanced Recovery Systems Limited facility at Chatham involved removal and disposal of the tailings pond residues. The section is developing capabilities in the mineral-beneficiation field, with particular emphasis on flotation. This will complement both the work being carried out by the mineralogical section and the expertise available in pyro- and hydrometallurgical processing.

The Mining Division of BMS requested that RPC prepare and strength test a number of concrete specimens in which Dalhousie power plant fly ash and ground boiler slag replaced the cement component of the mix. In addition, graded mine aggregate was used as a sand substitute and the strengths of all mixes were compared to the strength of a standard control mix. Substitutions of these admixtures occurred at 0, 15, 20, 25, and 30% levels. Results showed that in all cases, the mixtures possessed high enough compressive strength to be used as a backfill in the mining operation.

Amongst the merits of fluidized bed combustion technology is that of being able to use a wide variety of fuel types. This feature was utilized in a program on combustion which had as its first objective the generation of heat with thermal and manganiferous peat fuels. This objective was demonstrated successfully. In addition, the production of electrolytic manganese of high purity from the combustor ash could be economically viable. Plans are being formulated to test this possibility.

A project to investigate sulphur capture during circulating fluidized bed combustion of Eastern Canadian coals was started during the year. Funding for the project was obtained under the CANMET Energy Conversion Cost Shared Program. The Provincial Government provided full funding for the first phase, which has been completed, and 50% of the funding for the second phase. The primary objective of the study is to correlate the performance of the RPC unit with that of the Chatham demonstration CFBC of NBEPC. The first phase involved modification of the unit to reduce the inventory in the standpipe and an assessment of the effect of the ratio and location of primary/secondary air addition on combustor performance.

Presently, there are three Wood Energy projects in progress in New Brunswick under provincial and federal-provincial funding. The projects are a power station feasibility study, a study on the harvesting of unmerchantable woodlot stands for energy use, and a study on the economic availability of wood residue for energy conversion. RPC has been directly involved in the design and testing of combustor units, using wood as a fuel source.